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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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Volume 66
1956

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RICHARD A. LAUBENGAYER, Editor
Wabash College
Crawfordsville, Indiana

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Spring Meeting
May 11-12
BRADFORD WOODS

Fall Meeting
October 11-13, 1956
INDIANA UNIVERSITY

Published at Indianapolis, Indiana
1957

1. The permanent address of the Academy is the Indiana State Library.

2. **Instructions for Authors** appear at end of this volume, p. —.

3. **Exchanges.** Items sent in exchange for the Proceedings and correspondence concerning exchange arrangements should be addressed:

Indiana Academy of Science, Library
c/o State Library, Indianapolis 4, Indiana

4. **Proceedings** may be purchased through the State Library at $3.00 per volume.

5. **Reprints of technical papers** can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

6. The Constitution and by-laws reprinted from v. 62 and the Membership list reprinted from v. 61, are available to members upon application to the Secretary. Necrologies reprinted from the various volumes can be supplied relatives and friends of deceased members by the Secretary.

7. Officers whose names and addresses are not known to correspondents may be addressed care the State Library. The address of the editor of the present volume is Biology Department, Wabash College, Crawfordsville, Ind.

TABLE OF CONTENTS

Page

Officers and Committees for 1956 6
Minutes of the Spring Meeting 9
Minutes of the Executive Committee 12
Minutes of the General Session 18
New Members of the Year 1956 .... 19a
Junior Academy of Science 20
Necrology 27
Presidential Address—Raymond E. Girton 35

Anthropology

Abstracts of papers not published in full 45
E. J. BLASINGHAM—The "New England Indians" in the Western Great Lakes Region 47
R. B. JOHNSTON—Remarks on the physical type of certain Middle Mississippi and Southeastern Groups 50
F. X. GROLLIG—Pottery figurine heads from the Valley of Mexico 53

Bacteriology

Abstracts of papers not published in full 55
R. I. FLETCHER—An improved petri dish cover 57
R. V. DIPPELL and T. M. SONNEBORN—Structure of the Paramecium aurelia macronucleus as revealed by electron microscopy 60

Botany

Abstracts of papers not published in full 61
H. J. BRODIE—Raindrops as plant dispersal agents 65
J. DUNKIN and S. N. POSTLETHWAIT—The use of celloidin for the study of leaf surfaces 74

Chemistry

Abstracts of papers not published in full 77
R. B. FISCHER and S. KOSOLSOMBAT—Analysis by extraction and high frequency measurement 81
H. BURKETT, R. MURPHY and D. YARIAN—Acidity of trichloroacetic acid 86
C. E. OSBORNE, JR.—Determination of esters of acetylenic alcohols 91
A. W. MEIBOHM, S. BELLMAN and A. LETH—Coordination studies: dipyridylamine and 3,3′-iminobispropylamine 95
F. C. MATHERS—Aluminum solutions instead of ferric in qualitative testing for acetate 98

Entomology

Abstracts of papers not published in full 100
D. L. SCHUDER—A specific virus disease for control of the European pine sawfly, Neodiprion sertifer (Geoff.) 101
G. E. MARSHALL—Strawberry virus and insect vectors 103
J. J. DAVIS—Insects of Indiana in 1956 104
H. O. DEAY and J. G. TAYLOR—The sex of European corn borer moths taken at light traps 108

Page

L. CHANDLER—The Orders Protura and Diplura in Indiana 112
N. M. DOWNIE—Records of Indiana Coleoptera, I 115
B. E. MONTGOMERY—The anthophilous insects of Indiana: 1. A preliminary annotated list of the Apoidea 125
Three entomological laboratory techniques
  J. V. OSMUN—Rearing methods for subterranean termites 141
  H. B. MOORE and J. V. OSMUN—Circulation fans for fumigation chambers 143
  F. P. DIEHL and J. V. OSMUN—Chambers for exposure of roaches to chemically treated surfaces 144
G. E. GOULD—Wireworm populations as influenced by soil types 147
J. M. MACKLIN and B. E. MONTGOMERY—A separator for sampling the soil fauna 152

Geology and Geography
(including Soil Science)

Abstracts of papers not published in full 157
B. H. SCHOCKEL—A rigorous estimate of the economic importance of Indiana's counties 159
R. R. DRUMMOND—A comparative study of rural level-of-living indexes in Indiana Counties 167
B. ZAKRZEWSKA—Woodlands in Monroe County, Indiana 170
J. M. SMITH and H. H. MURRAY—The clay minerals in some glacial lacustrine sediments of Indiana 179
S. S. VISHER—Water supply problems of Bloomington, Indiana 188
O. P. STARKEY—Road patterns of Indiana 192
J. F. HART—Migration and population change in Indiana 195
A. LAL—Population trends in Indiana's villages of 1,000-2,500 population in 1950 204
A. H. MEYER and P. F. MILLER—Manufactural geography of Chicago Heights, Illinois 209

Soil Science (Affiliate)

Abstracts of papers not published in full 230
J. L. WHITE, G. TALVENHEIMO, M. G. KLAGES and M. M. PHILLIPPE—A survey of the mineralogy of Indiana soils 232
S. A. BARBER—Measurement of the fineness of agricultural limestone 242
T. M. BUSHNELL—Trials of the catena-drainage profile keyform as a frame of reference in pedological taxonomy 246

History of Science

Abstracts of papers not published in full 252
S. S. VISHER—Aspects of conservation on man in Indiana 254
W. J. TINKLE—Conservation of germplasm of domestic species 256
D. DENUYL—History of forest conservation in Indiana 261
H. H. MICHAUD—Conservation of recreational and scenic resources .. 268
S. D. GERKING—A history of the study of fishes in Indiana 275
C. H. BECHERT—History of water conservation in Indiana 286
R. O. Cole—A chronological history of the soil conservation service and related events 291

Mathematics

Division did not meet.

Physics

Page
Abstracts of papers not published in full 297

Plant Taxonomy

Abstracts of papers not published in full 300
C. A. MARKLE—Contributions to the flora of Wayne County, Indiana, II 301
J. O. COTTINGHAM—Higher fungi of Marion County, Indiana, VIII .. 305
R. C. JACKSON and A. T. GUARD—Analysis of some natural and artificial interspecific hybrids in Helianthus 306
L. FARQUHARSON and M. S. MARKLE—Botanical forays to Florida 318
M. T. HALL—Variation in the genus Hudsonia 321

Psychology

Abstracts of papers not published in full 323

Zoology

Abstracts of papers not published in full 328
W. C. GUNTHER—Some dietary effects on the estrous cycle of the female California pocket gopher, Thomomys bottae navus Merriam 331
J. D. WEBSTER—A new race of wood pewee from Mexico 337
B. E. BEEKMAN—The effect of crystalline glucagon on the blood sugar of the fowl 341

Appendix

Instructions for contributors 346
Index to Volume 66 348

Officers and Committees for 1956

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Vice-President	John Mizelle, University of Notre Dame
Secretary	W. A. Daily, Eli Lilly and Company
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Editor	R. A. Laubengayer, Wabash College
Press Secretary	J. A. Clark, Department of Conservation, Indianapolis

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Plant Taxonomy	C. A. Markle, Earlham College
Psychology	J. P. Egan, Indiana University
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Chairmen of Standing Committees)

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BUDGET COMMITTEE

(President, Secretary, Treasurer, Editor, and Chairmen of Committees
on Junior Academy, Library, Program and Relation
of Academy to State)

R. E. Girton, W. A. Daily, F. J. Welcher, R. A. Laubengayer, H. H. Michaud, N. M. Coats, C. B. Heiser and F. N. Wallace.

COMMITTEES ELECTED BY THE ACADEMY

Trustees of the Academy Foundation (term 4 years): Chairman, R. N. Harger, Indiana University School of Medicine, Indianapolis (term expires 1956); Ward J. Rice (term expires 1960).

Bonding of Trustees (elected annually): Chairman, Scott McCoy, Technical High School, Indianapolis; W. P. Morgan.

Research Grants (term 5 years): Chairman, T. G. Yuncker, DePauw University (term expires 1959); W. H. Johnson (1957), M. G. Mellon (1960), Paul Weatherwax (1956), J. F. Mackell (1958); R. E. Girton and W. A. Daily *(ex officio)*.

STANDING COMMITTEES

(Appointed by the President)

Auditing: Chairman, W. P. Morgan, Indiana Central College; S. E. Elliott.

Biological Survey: Chairman, Winona H. Welch, DePauw University; F. K. Daily, D. G. Frey, C. J. Goodnight, C. A. Markle, H. H. Michaud, S. A. Minton, F. N. Young.

Fellows: Chairman, A. T. Guard, Botany, Purdue University; H. M. Powell, Bacteriology; C. F. Voeglin, Anthropology; M. G. Mellon, Chemistry; H. O. Deay, Entomology; T. F. Barton, Geology and Geography; S. S. Visher, History of Science; P. D. Edwards, Mathematics; J. F. Mackell, Physics; F. K. Daily, Plant Taxonomy; H. H. Remmers, Psychology; W. R. Breneman, Zoology.

Index: Chairman, R. A. Laubengayer, Wabash College; N. M. Coats, F. N. Wallace.

Indiana Talent Search: Chairman, R. W. Lefler, Purdue University; L. H. Baldinger, P. D. Edwards, T. W. Torrey, W. H. Welch; H. H. Michaud and R. E. Girton *(ex officio)*.

Invitations: Chairman, R. E. Cleland, Indiana University; W. H. Johnson, B. H. Smith.

Junior Academy: Chairman, H. H. Michaud, Purdue University; N. E. Adams, R. Cooper, J. Cope, S. D. Gerking, P. E. Klinge, Lola Lemon, R. McDougal, R. E. Martin, R. E. Niswander, M. Stork; R. W. Lefler and R. E. Girton *(ex officio)*.

Library: Chairman, N. M. Coats, State Library; Eli Lilly, M. G. Mellon.

Membership: Chairman, H. R. Youse, DePauw University; J. O. Cottingham, H. E. Crull, A. L. Delisle, Lois Farquharson, M. Garner, W. H. Headlee, Z. Hurlbut, R. L. Kent, W. G. Kessel, E. Kintner, R. G. Larson, R. E. Martin, L. S. McClung, D. E. Miller, J. Pelton, E. C. Williams.

Necrologist: W. E. Edington, DePauw University.

Nominating: Chairman, A. H. Meyer, C. L. Porter, P. D. Edwards.

Program: Chairman, C. B. Heiser, Indiana University; C. E. Kaslow, J. D. Mizelle, J. Pelton, T. G. Perry, E. D. Weinberg, F. N. Young.

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Publicity: Chairman, J. A. Clark, Department of Conservation; D. C. Peaslee, R. C. Starr; H. Hazelrigg and D. H. Radler *(ex officio)*.

Relation of Academy to State: Chairman, F. N. Wallace, Department of Conservation; J. A. Clark, Eli Lilly, H. J. Reed.

Representative on Council of the A.A.A.S.: R. W. Lefler, Purdue University.

Representative on the Indiana Committee for Pine Hills of the Nature Conservancy: A. A. Lindsey, Purdue University.

Resolutions: Chairman, F. K. Daily, Butler University; O. B. Christy, H. M. Powell.

Science Education: Chairman, R. R. Armacost, Purdue University; Catherine W. Dale, W. H. Johnson, P. E. Klinge, R. W. Lefler.

Science Youth Financing: Chairman, R. W. Lefler; R. R. Armacost, C. W. Dale, R. McCord, H. H. Michaud, F. J. Welcher, R. Morgan (advisory); (ex officio) R. E. Girton, R. W. Schulz.

MINUTES OF THE SPRING MEETING

BRADFORD WOODS
Martinsville, Indiana
May 11-12, 1956

President R. E. Girton called the Executive Committee Meeting to order at 4:45 P. M. in the Bradford Manor. Twenty-five members, including seven past presidents, were present.

The officers and committees reported as follows:

Treasurer: F. Welcher stated that his full report would appear in the current issue of the proceedings.

Editor: R. A. Laubengayer reported that all the galley proofs were in the hands of the printer and page proofs expected soon.

Library: Nellie M. Coats gave the following report: "Something of the value of the Academy Library's part in the education of young scientists may be judged from the number of items sent on interlibrary loan to universities for the use of graduate students. There is, too, a continuation of frequent use by those now engaged in research in industry and in such agencies of government as the Naval Ordnance Plant, Indianapolis.

"To further usefulness of the collection, titles and holdings are to be recorded in the 1950-1955 cumulation of New Serial Titles, a union list showing what serials are in what libraries. This checking is now in process. In addition Mrs. Burton is compiling a list of titles currently received together with holdings which it is hoped will be available for distribution to members at the fall meeting."

Press Secretary: J. Clark remarked that publicity for the meeting had been released by newspapers and by radio.

Program Chairman: Charles B. Heiser stated that plans were complete for the spring meeting and well under way for the fall meeting at Indiana University.

Membership Committee: A tentative list of 17 applicants for membership was given by H. R. Youse.

Science Talent Search: Winona Welch thought the latest Science Talent Search meeting held in Indianapolis was a very impressive affair with many fine young high school students in attendance. Dr. R. Lefler was praised highly by the committee members present for his excellent guidance in this work.

Science Education Committee: W. H. Johnson discussed the work accomplished during the first meeting of this committee.

The recommendations given are as follows:

1. Increased emphasis on teaching problems in existing sections of the Academy.

2. The two major state universities should assume leadership in increasing the offerings of the science department of the colleges and universities in the state for in-service teachers.

3. The committee recommends that the administration of research grants provided by the A.A.A.S. and designated for high-school research be administered by the Indiana Science Talent Search Committee until the Executive Committee of the Academy works out a permanent method of administering these funds.

The following letter from Mrs. Esther Potzger was received by the secretary of the Academy: "Sincere thanks for your remembrance at this time. I know my husband deeply appreciated the many friends, the association over many years and the fine support given his research by the Academy."

New Business:

1. It was recommended that Mr. Charles Ek of Spencer, Indiana, be made an Emeritus Member and receive the Proceedings of the Indiana Academy of Science.

2. Following a report by Frank Welcher, the president, R. E. Girton, recommended that a special committee be appointed to study the financial situation of the Academy.

3. In the absence of R. E. Cleland, an invitation to hold the 1957 fall meeting of the Academy on the DePauw University campus was given by Charles Heiser, Jr.

4. W. H. Johnson offered the following suggestions:

a. The Academy fall meeting program should perhaps include symposia concerning high school teaching methods.

b. A special committee to be appointed by the president for the purpose of soliciting and distributing funds on behalf of the Indiana Science Talent Search.

All reports were accepted.

The meeting was adjourned at 6:15 P. M.

Dinner Meeting: Following the dinner in the dining lodge, the business meeting was called to order by President Girton at 7:30 P. M.

Following words of welcome to the spring foray group, the officers and their wives were introduced to the assemblage. Out-of-country visitors were Ing. Agr. Dr. Jorge Soria V from Quito, Ecuador, and Dr. Helmut Müller of Hanover, Germany.

The president announced that the Soils Society was being reactivated and would meet with the Academy in the fall.

Twenty-three applicants for membership were duly elected.

Mr. R. Tully, director of Bradford Woods, gave a very interesting history of the area and the Bradford family who donated the land to the James Whitcomb Riley Hospital for Children. The grounds are being developed by Indiana University and the James Whitcomb Riley Memorial Association as an educational and recreational center for the children of Indiana.

Mrs. Fay K. Daily, chairman of the Resolutions Committee, read the following report, "The Resolutions Committee, speaking on behalf of the Indiana Academy of Science, wishes to thank the management of Bradford Woods and the Program Committee for their many fine arrangements, the participants in the program and leaders of hikes for their earnest preparation necessary to make this meeting a success, Also, we wish to thank the officers for their efficient service."

Dr. David G. Frey, Indiana University, then presented an excellent illustrated lecture entitled "The Cultivation of Fish for Food in Indonesia."

Announcements of the field trips for Saturday morning were given by H. H. Michaud, William C. Martin, Jr., John Pelton, and John B. Patton.

Seventy-seven members signed the Academy roll.

All scheduled hikes were made on May 12 in fine weather.

W. A. DAILY,
Secretary

MINUTES OF THE EXECUTIVE COMMITTEE

INDIANA UNIVERSITY, OCTOBER 11, 1956

The Executive Committee of the 72nd session was called to order by President Girton in Jordan Hall at 7:30 P. M.

The minutes of the Spring Meeting, held at Bradford Woods near Martinsville, Indiana, were read and approved.

The reports of officers and committee representatives were presented and accepted as follows:

Treasurer. Dr. Frank Welcher gave the following tentative financial report for the period January 1, 1956, to December 31, 1956. This and the 1955 report have not been audited.

Receipts

1.	Balance on hand, January 1, 1956	$1,385.66	
2.	Dues and initiation fees	1,897.00	
3.	Publications sold	32.50	
4.	A.A.A.S. refunds for research grants	300.00	
5.	Author's reprints Vol. 62	8.27	
6.	Author's reprints Vol. 63	17.72	
7.	Author's reprints Vol. 64	351.75	
8.	Author's reprints Vol. 65	467.07	
9.	For printing results of Biological Survey Questionnaire	25.50	
10.	Designated gift	150.00	
11.	Talent Search	1,990.00	
			$6,621.47

Disbursements

1.	Editor Vol. 65	$ 191.21	
2.	Expenses of President	6.34	
3.	Expenses of Secretary	197.56	
4.	Expenses of Treasurer	178.40	
5.	Stationery	108.75	
6.	Talent Search	1,990.00	
7.	Program Committee	318.85	
8.	Research grants	237.50	
9.	Secretary of State	1.00	
10.	Refund on reprints	3.13	
11.	Mailing Proceedings Vol. 65	131.76	
12.	Returned check	4.00	
13.	Expenses of five officers as directed by action of 1947 Executive Committee	100.00	
14.	Author's reprints Vol. 65	80.33	
15.	Binding, Academy of Science Library	692.65	
16.	Surety Bond	62.50	
17.	Academy Conference	11.00	
18.	Publication of Proceedings, Vol. 64	493.68	
19.	Science Education Committee	10.00	
			$4,814.66
	Balance on hand, December 31, 1956		1,806.81
			$6,621.47

Editor and Publication of Proceedings. Dr. Richard A. Laubengayer reported 1200 bound and 600 unbound copies of the 1956 Proceedings were prepared. Reprints have been sent out to authors or are in the mail.

Trustees of the Academy Foundation. The secretary presented the report for October 1, 1955 to September 30, 1956:

Oct. 1, 1955. Beginning balance	$ 801.74
Oct. 1, 1955 to Sept. 30, 1956. Total receipts	380.86
Oct. 1, 1955 to Sept. 30, 1956. Bank fees	19.04
Sept. 30, 1956. Ending cash balance	1,155.08
Bonds and shares of stock. Total carrying value	$13,412.00

Press Secretary. James Clark reported that notices of our meeting were sent to scientific magazines, newspapers and radio stations. Abstracts of special topics were sent to reporters and columnists who proposed to use the material.

The committee has functioned more satisfactorily than would have been possible for the Press Secretary alone.

We have had two feature articles in newspapers during the year concerning the Academy.

A television program has been arranged by Hugh Hazelrigg which will feature the Academy.

Research Grants. Dr. T. G. Yuncker gave the following report:

The A.A.A.S. has recently decided to utilize the money formerly placed at the disposal of this committee to the promotion of research at the high school level. It is the understanding of the committee that there will continue to be some money available for our grants during the period of transition in policy. It is also possible that the Academy may be able to support adult research to some extent.

During the past year the following grants have been made:

One hundred dollars to Mrs. Carrolle A. Markle of Earlham College to be used in connection with her work on the Wayne County flora.

One hundred dollars to William B. Eberly of Manchester College to aid him in his research on the crustacea of Indiana.

The committee will entertain requests for small grants up to the limit of money available for this purpose.

Nominations. Dr. A. H. Meyer reported the following nominations: Mr. Ward J. Rice to serve as chairman of the Academy Foundation Committee and Mr. John Seybert to be the second member. Dr. W. P. Morgan to serve as chairman of the Bonding of Trustees Committee and Mr. Scott McCoy to be the second member. Dr. Paul Weatherwax to serve another term on the Research Grants Committee.

Fellows. Dr. A. T. Guard and his committe nominated the following Academy members to be elected to the rank of Fellow:

Mr. James A. Clark, State Entomologist's office, Indianapolis, Ind.
Dr. Richard A. Laubengayer, Wabash College, Crawfordsville, Ind.
Dr. Carrolle Anderson Markle, Earlham College, Richmond, Ind.
Dr. John D. Mizelle, University of Notre Dame, Notre Dame, Ind.
Dr. Thomas B. Noble, Physician, Indianapolis, Ind.

Biological Survey. Dr. Winona Welch presented a report of progress and of completion. Dr. Clarence J. Goodnight has continued studies on the arachnids of the state, particularly the Opilionids, which is a continuation of a larger project. One of his students, Mr. Parthasarathy has concluded a study of the chromosomes of some Opilionids of Indiana, a part of the larger arachnid project. Dr. Frank N. Young has continued work on the Indiana Coleoptera. One of his students, J. R. Zimmerman, is studying the water beetle genus, Laccophilus, especially as to habits and as to the distribution of the species in the state. Dr. Sherman A. Minton, Jr., has tried unsuccessfully to have published his manuscript of a book on the *Herpetology of Indiana.* He is now preparing an annotated key for the naturalists to use as a guide to the reptile and amphibian fauna of the state. Dr. Minton and Dr. Philip W. Smith of the Illinois Natural History Survey have completed a distributional study of reptiles and amphibians in Illinois and Indiana. The manuscript has been submitted for publication. A book appeared this past year, contributing to the knowledge of Indiana algae and their distribution, the *Revision of the Coccoid Myxophyceae* by Francis Drouet and William A. Daily. Fay K. and W. A. Daily have continued their studies of Indiana algae. Mr. Daily has in press a paper on a dinoflagellate not reported from Indiana previously. *Mosses of Indiana,* an illustrated manual, by Winona H. Welch, is now in press.

Library. Miss Nellie M. Coats gave the following report:

Clear evidence of the growth of the Academy's library is contained in lists of serials received compiled at intervals. A 1935 list recorded 226 titles, a 1949 list was made up of 496 titles, a list processed by Lois Burton of the State Library Staff for distribution at this 1956 session totals 828 titles. That many of these serials are not too widely held in American libraries is indicated by requests for loans from such widely separated agencies as the Quartermaster Research and Development Center at Natick, Massachusetts; the University of Arizona; the University of Minnesota; Marshall College, Huntington, West Virginia; and the Canadian Department of Agriculture at Ottawa. Of course, items are in frequent demand from Indiana research workers and graduate students.

The library provided labor and envelopes for mailing 946 copies of V. 65 for 1955 to 915 individual members and to 31 junior academies. Publication date is recorded as September 25, 1956. The volume will be mailed shortly to Indiana libraries and to other agencies.

Some particularly nice items were received in exchange including Munro. *Marine and freshwater fishes of Ceylon;* Prescott. *Collections of a century,* a centennial publication from the National Museum of Victoria and a volume on the mammals of Victoria. Dr. T. G. Yuncker presented a copy of his and Dr. Trelease's two volume work on Piperaceae of Northern South America along with a group of reprints on this subject. Dr. Yuncker also contributed several out-of-print issues of the I.A.S. Proceedings.

One hundred-ninety-three volumes in the Academy's library have been prepared for binding at an estimated cost of $692.95.

By courtesy of the Indiana State Library your librarian represented the Academy's Library at the National Special Libraries Association meeting in Pittsburgh in June.

Relation of the Academy to State. Mr. Frank N. Wallace reported that the Legislature would be asked to appropriate $4,000.00 for the publication of next year's Proceedings.

Invitations. Dr. Ralph Cleland received an invitation to hold the 1957 meeting on the campus of DePauw University.

Membership. Dr. H. R. Youse presented a preliminary total of 33 nominees for membership in the Academy.

Program. Dr. Charles B. Heiser, Jr., reported that all arrangements had been completed for the meeting.

Junior Academy. Dr. H. H. Michaud reported that the twenty-third annual meeting of the Indiana Junior Academy of Science was held Saturday, October 15, 1955, at the University of Notre Dame. Three hundred and eighty high school students, teachers and guests registered at the meeting. This was the largest attendance of any Junior Academy meeting ever held with the exception of the combined conference with the Purdue Sci-Math Assembly held the previous year at Purdue.

The program included talks on careers in science by faculty members of the Notre Dame staff, visits to instructional and research laboratories and the usual exhibits and papers by members of high school science clubs. The opportunity to visit with the staff and to see the progress of scientific research at the University is stimulating to high school students and teachers.

Three new science clubs have been enrolled in the Junior Academy since the last report. They include the Science Club, Lincoln High School, Highland; the Phi-Chem Club, Our Lady of Providence High School, Clarksville; and the Junior Academy of Science Club, South Side High School, Fort Wayne. There are forty-seven clubs listed on the present roll of the Junior Academy.

The twenty-fourth annual meeting of the Junior Academy will convene this Saturday, October 13. The entire program of exhibits, papers and career conferences will be held at Jordan Hall. We are especially grateful for the splendid cooperation of Dr. Charles B. Heiser, Chairman of the Program Committee, and the members of the University staff for the special arrangements for student conferences in science and conducted visits to scientific laboratories.

Fourteen papers by Junior Academy members will be read during the afternoon session.

The Junior Academy of Science deserves a fair share of credit for promoting interest in science projects that lead toward greater participation in the regional and national science fairs, and the state and national science talent searches. Many of the students who have entered one to several of these activities during their secondary school years have become top ranking students at the college level. Many have already reached the professional status in their scientific careers.

As State Sponsor, I would like to extend a special invitation to everyone to attend the program of the Junior Academy tomorrow.

Representative on Council of A.A.A.S. Dr. Ralph Lefler attended the meetings of the council and Academy conference. The 1957 annual meeting is to be held in Indianapolis. An experimental program for encouraging the development of high school science libraries is in effect. Indiana high schools are participating. The science teacher improvement program of the A.A.A.S. has a grant of $300,000 to support their 5-point program with principal emphasis on the sciences. Detailed information is to be found in issues of *Science*.

Indiana Science Talent Search. One hundred thirty-four (134) high school seniors completed entry requirements for the 1955-56 Science Talent Search. This is a gain of 28 students over the previous year.

One hundred nineteen (119) of these students will attend 37 colleges, 90 in 17 Indiana colleges and 23 in 20 out-of-state schools.

The search in Indiana has encouraged colleges and universities to make scholarship aid available to participants who must have financial aid to attend college. Scholarship aid to these students amounts to more than 30 times the cost of the search, or our cost of operation amounts to only 3.1% of the total scholarship aid which these students will receive.

The culminating program for participants, The Junior Scientists' Assembly, was held on March 24, 1956, in Indianapolis. In addition to the exhibit of projects by the Indiana Winner-Honorable Mention Group and the usual program at the Honor's Luncheon, our Winner-Honorable Mention students and their sponsoring teachers were the guests of the Research Division of the Eli Lilly Company during the day, Friday, March 23, and of the Allison Division of General Motors for Friday evening.

State wide news coverage was provided by the *Indianapolis News* and the *Indianapolis Times*.

We are grateful for the financial support provided by the Allison Division of General Motors, the Eli Lilly Company and the Indianapolis Industrial Exposition, an activity of the Indianapolis Chamber of Commerce.

We expect to hold the Junior Scientists' Assembly for this school year on March 23, 1957.

A unanimous vote of appreciation was given Dr. Winona H. Welch for her service on this committee, as she finds it necessary to withdraw because of other added duties.

Dr. Lefler also reported on the eight Science Fairs held in Indiana during the spring of 1956. Two finalists from the Senior division were chosen in each of the eight Regional Fair areas. These finalists, accompanied by their sponsoring teachers, the director of the Regional Fair, and a newspaper representative from the region made the trip to Oklahoma City for the National Science Fair in May on planes which were chartered by the Indiana Medical Association at a cost of about $3500.

It is expected that more than 1000 Indiana students will participate in Indiana regional science fairs during this school year.

Financing of the Academy Science Youth Program. Professor Lefler outlined possible ways and means of raising funds for this work.

Science Education Committee. Dr. R. Armacost recommended that the name of this committee be changed to "Science Teaching Improvement Committee" and an annual program initiated.

Financial Status of Academy. Dr. P. D. Edwards read the proposal of his committee that the annual dues for members of the Indiana Academy of Science be increased from $2.00 per year to $4.00 per year. A student member classification to be established for undergraduate students at $2.00 per year to become effective in 1957.

New Business.

Upon recommendation of Dr. Frank Welcher, treasurer, dues will not be collected, except those of new members, during this meeting.

The meeting adjourned at 10:45 P. M.

W. A. DAILY, Secretary

MINUTES OF THE GENERAL SESSION

INDIANA UNIVERSITY, OCTOBER 12, 1956

Dr. John W. Ashton, Vice-President of Indiana University, welcomed the Indiana Academy of Science to the Bloomington campus. A response was given by Dr. Raymond E. Girton, President of the Indiana Academy of Science.

The minutes of the Executive Committee were read and approved.

Dr. O. B. Christy presented a short biographical sketch of members who had died during the year. They were: William M. Tucker, Bert R. Mull, Sayers J. Miller, Albert R. Bechtel, Alfred C. Kinsey and William Lowe Bryan.

Dr. Charles Deiss, Chairman of the Department of Geology, Indiana University, presented an illustrated lecture entitled, "Geology of Indiana's Mineral Resources."

The meeting adjourned at 10:45 A. M.

Sectional meetings then began with a recess for lunch, after which meetings were resumed.

The annual dinner was held in Rooms A, B, C, and D, Union Building.

Vice-President John Mizelle introduced the guests and officers at the speakers' table. It was noted that Dr. T. G. Yuncker and Dr. Ralph E. Cleland had received Golden Jubilee Merit Citations from the American Botanical Society during its 50th anniversary banquet at the University of Connecticut, August 29, 1956.

Mrs. Fay K. Daily presented the following resolutions:

Whereas:

The Indiana Academy of Science was invited to hold its 72nd annual meeting at Indiana University where careful preparation and hospitality have made our visit both comfortable and rewarding, and

Whereas:

We have been privileged to visit the new Jordan Hall, a beautiful and commodious structure which will be of great value in continuance of the high quality of work done by the scientific staff and students of Indiana University, be it

Resolved:

That President Herman B Wells be thanked for his welcome to Indiana University campus; that Dr. C. B. Heiser, Jr., and his committee receive our heartfelt appreciation for the various appointments; that our officers and many other committees, general program speakers, as well as sectional chairmen be commended for their efforts to make this a very successful meeting.

It was recommended that a copy of these resolutions be sent Pres. Wells and Dr. Heiser.

Dr. H. R. Youse presented a tentative list of 50 applicants for membership. These were duly elected.

The Nominations Committee report was given by the chairman, A. H. Meyer. Divisional Chairmen for 1957 will be: Anthropology, Dr. William R. Adams, Bloomington, Indiana; Bacteriology, Dr. Edward W. Shrigley, Indiana University; Botany, Dr. Alton A. Lindsey, Purdue University; Chemistry, Dr. Robert B. Fischer, Indiana University; Entomology, Mr. Howard O. Deay, Purdue University; Geology and Geography, Dr. T. G. Perry, Indiana University; History of Science, Prof. Daniel Den Uyl, Purdue University; Mathematics, to be appointed; Physics, Prof. Malcolm Correll, DePauw University; Plant Taxonomy, Dr. John E. Pelton, Butler University; Psychology, Dr. Kenneth M. Michels, Purdue University; Zoology, Dr. Eliot Williams, Wabash College.

The following members were recommended to serve as 1957 officers: President, Dr. Willis H. Johnson, Wabash College; Vice-President, Mr. W. A. Daily, Eli Lilly and Company; Secretary, Dr. Harry E. Crull, Butler University; Treasurer, Dr. Frank Welcher, Indiana University, Adult Education Center, Indianapolis; Editor, Dr. Richard A. Laubengayer, Wabash College; Press Secretary, Mr. James Clark, Conservation Department, Indianapolis.

President Girton gave his presidential address entitled, "The Capture and Use of Sunlight."

The 72nd annual fall meeting of the Indiana Academy of Science with a general attendance of 431 and a dinner attendance of 102 was adjourned.

W. A. DAILY,
Secretary

INDEX

NEW MEMBERS FOR 1956

Barber, Dr. Stanley A., Agronomy Department, Purdue University, West Lafayette, Ind. G
Barton, Dr. Jay II, St. Joseph's College, Collegeville, Ind.
Bechert, Charles H., Indiana Department of Conservation, 311 W. Washington St., Indianapolis, Ind. G, H of S
Bell, Prof. Marvin R., Indiana State Teachers College, Terre Haute, Ind. G, Bo
Bessy, Dr. William, Butler University, Indianapolis, Ind. Ph
Biebel, Mr. Paul Joseph, Botany Department, Indiana University, Bloomington, Ind. Bo
Borrini, Dr. Tiziano, Corso Cavour 2, Novara, Italy Bio
Boyer, Mr. Marion Clifford, 1330 W. Michigan St., Indianapolis, Ind. G
Brammer, Beatrice Hicks, 85 W. Sixth St., Peru, Ind. Bac
Bray, Ralph, Physics Department, Purdue University, West Lafayette, Ind. Ph
Bretscher, Dr. Manuel Martin, Department of Physics, Valparaiso University, Valparaiso, Ind. Ph
Brett, Dr. William John, Indiana State Teachers College, Terre Haute, Ind. Zo
Brumbaugh, Mr. Joe H., Department of Botany, Wabash College, Crawfordsville, Ind. PT

Creek, Mr. Robert Omer, Zoology Department, Indiana University, Bloomington, Ind. Zo

Deters, Mr. John F., Valparaiso University, Valparaiso, Ind. Ch
Diehl, Mr. Frederick P., 3803 Gettysburg Road, Camp Hill, Pa. Ent
Duncan, Mr. W. G. III, 219 Lincoln St., West Lafayette, Ind.
Dunkin, Mr. Joseph S., 235 E. Main, Flora, Ind. Bo

Edington, Mr. John Ward, R. R. 1, Straughn, Ind. Bac

Fan, Prof. Hsu Yun, Physics Department, Purdue University, West Lafayette, Ind. Ph
Ferm, Dr. Vergil Harkness, Anatomy Department, Indiana University, Bloomington, Ind. An, Zo
Fraser, Prof. Dean, Bacteriology Department, Indiana University, Bloomington, Ind. Bac

Gaddis, Dr. S. W., Indiana State Teachers College, Terre Haute, Ind. Ch
Gerritsen, A. N., Physics Department, Purdue University, West Lafayette, Ind. Ph, H of S
Gillman, Prof. Leonard, Purdue University, West Lafayette, Ind.
Grollig, Rev. Francis X., S. J., West Baden College, West Baden Springs, Ind. Ant

Hall, Dr. Marion T., Botany Department, Butler University, Indianapolis, Ind. PT
Hanson, Dr. Robert J., Biology Department, Valparaiso University, Valparaiso, Ind. Bac
Hook, Dr. John C., Indiana State Teachers College, Terre Haute, Ind. G
Humbles, Mr. Jack E., R. R. No. 1, Fortville, Ind. Zo, Bo
Johnson, John Irwin, Jr., Psychology Department, Purdue University, West Lafayette, Ind. Psy
Johnson, Dr. Orland E., Physics Department, Purdue University West Lafayette, Ind. Ph
Johnston, Mr. Richard Barnett, 7450 Holliday Drive East, Indianapolis, Ind. Ant
Keesom, P. H., Purdue University, West Lafayette, Ind. Ph
King, Richard Wayne, Physics Department, Purdue University, West Lafayette, Ind. Ph
Klages, Dr. Murray, Agronomy Department, Montana State College, Bozeman, Mont.
Knoebel, Dr. Kenneth, Physiology Department, Indiana University, Bloomington, Ind. Zo
Kolitschew, Dr. Konstantin, Indiana Central College, Indianapolis, Ind. M, Ph
Kosolsombat, Mr. Samak, 2 Bangchan, Nimburi, Bangkok, Thailand Ch
Kowitz, William T., Geography-Geology Department, Valparaiso University, Valparaiso, Ind. Ge
Krueger, Mr. Thos. P., Anatomy Department, Indiana University, Bloomington, Ind. Zo
Lal, Mr. Amrit, Geography Department, Indiana University, Bloomington, Ind. G
Leth, Miss Arlene, 600 Valley Road, Itasca, Ill. Ch
Long, Mr. Michael, Anatomy Department, Indiana University, Bloomington, Ind. Zo
Lowry, Dr. Murrill M., Butler University, Indianapolis, Ind.
McCoy, C. Edward, Purdue University, West Lafayette, Ind. Ent
Michael, Edward V., R. D. No. 1, Imperial, Pa. Ant
Malin, Bernard, Eli Lilly & Co., Dept. M-782B, Indianapolis, Ind. Bac
Manning, Prof. Armin William, Valparaiso University, Valparaiso, Ind. Ph
Martin, William C., Jr., Botany Department, Indiana University, Bloomington, Ind. Bo
Meyer, L. R., 311 W. Washington St., Indianapolis, Ind. Bo., Ent, G
Michels, Dr. Kenneth, Purdue University, West Lafayette, Ind. Psy
Milne, C. G., 1913 N. Meridian St., Apt. 3, Indianapolis, Ind. Bo
Moore, Harry B., Reliable Exterminators Inc., Lafayette, Ind. Ent
Murphy, Ira Arthur, Chemistry Department, Indiana University, Bloomington, Ind. Ch
Murphy, Richard Bullock, Department of Chemistry, University of Washington, Seattle, Wash. Ch

Nelson, Werner L., American Potash Institute, Life Building, West Lafayette, Ind. G

Osborn, Stephen Wynn, Chemistry Department, Indiana University, Bloomington, Ind. Ch

Owen, Dr. Oliver, Anderson College, Anderson, Ind. Zo

Paschall, Homer, Ball State Teachers College, Muncie, Ind. Bi

Pearlman, Norman, Physics Department, Purdue University, West Lafayette, Ind. Ph

Pettay, Louanna, Anthropology Department, Indiana University, Bloomington, Ind. Ant

Phillips, Marjorie Louise, Botany Department, Indiana University, Bloomington, Ind. Bo

Phillippe, Dr. Maurice M., Agronomy Department, Clemson Agricultural College, Clemson, S. C.

Polzin, Wm. J., Eli Lilly & Co., 702 S. Alabama St., Indianapolis, Ind. Bac, Bo

Proffitt, Max Arthur, Indiana State Teachers College, Terre Haute, Ind. Zo

Ramsey, Viola, R. R. 9, Bloomington, Ind. Ch

Rees, James Richard, Anderson College, Anderson, Ind. Bo

Schatzlein, Frank, Zoology Department, Indiana University, Bloomington, Ind. Zo

Schramm, J. R., Botany Department, Indiana University, Bloomington, Ind. Bo

Schwark, Mrs. Sylvai D., Apt. 3, 179 Cambridge Blvd., Buffalo, N. Y. Ch

Shay, J. R., Botany Department, Purdue University, West Lafayette, Ind. Bo

Sheets, Albert, Jr., Center Grove High School, R. R. 3, Greenwood, Ind. Zo

Siverly, Dr. R. E., Ball State Teachers College, Muncie, Ind. Ant

Smith, John M., Indiana Geological Survey, Indiana University, Bloomington, Ind. G

Smith, Robert E., Zoology Department, Indiana University, Bloomington, Ind. Zo

Stanley, Robert W., Physics Department, Purdue University, West Lafayette, Ind. Ph

Stevenson, Dr. Forrest F., Ball State Teachers College, Muncie, Ind. Bo

Swisher, Carl L., 412 N. Dill, Muncie, Ind. G

Talvanheimo, Dr. Gerhardt, Houdry Process Corporation, Marcus Hook, Pa.

Thornburg, Noel G., 219 N. Couluert St., Muncie, Ind. Bo

Turbes, Calvin C., Department of Anatomy, Indiana University, Bloomington, Ind. Ch

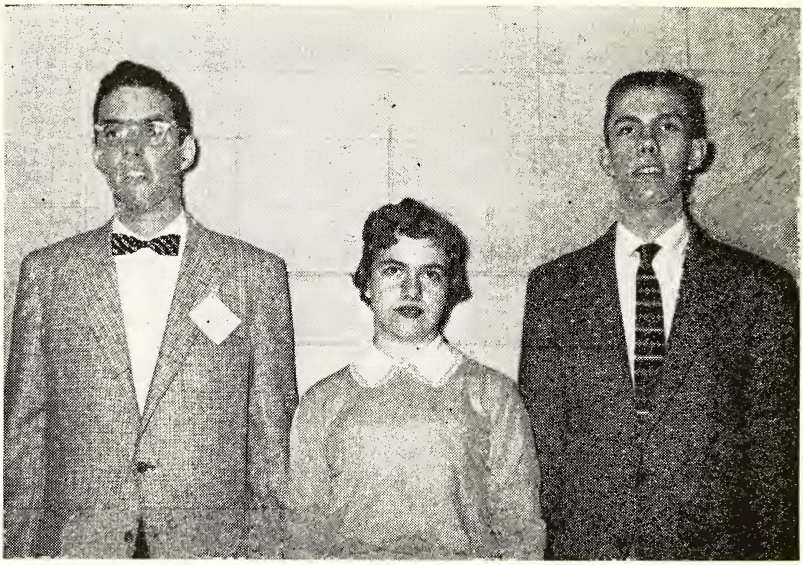
White, Harold K., Box 273, Hanover, Ind. Ch

White, Joe Lloyd, Agronomy Department, Purdue University, West Lafayette, Ind. G

Worrell, Francis T., Physics Department, DePauw University, Greencastle, Ind. Ph
Yarian, Dean Robert, Department of Chemistry, University of Washington, Seattle, Wash. Ch
Zakrzewska, Miss Barbara, Geography Department, Indiana University, Bloomington, Ind. G
Zeller, Frank J., Zoology Department, Indiana University, Bloomington, Ind. Zo
Zimmerman, Harold A., 2218 Linden St., Muncie, Ind. Zo

INDIANA JUNIOR ACADEMY OF SCIENCE

Junior Academy of Science, South Side High School, 3500 S. Calhoun, Fort Wayne, Ind. All branches
Providence Phy-Chem Club, Our Lady of Providence High School, State Highway No. 62, Clarksville, Ind. Ch



Officers of the Junior Academy of Science for 1956: (l. to r.) President, Roger Cuffey, University High School, Bloomington; Secretary, Paula Erpelding, Central Catholic High School, Fort Wayne; Vice-President, Brett Nordgren, Central Junior-Senior High School, South Bend.

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS FOR 1956

President: Roger Cuffey, Science Club, University High School, Bloomington.

Vice President: Brett Nordgren, Science Club, Central Junior-Senior High School, South Bend.

Secretary: Paula Erpelding, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne.

Members of the Council: Charles E. Karst, Mishawaka (1952-1956); Edith Wallace, Gary (1953-1957); Jerry Motley, Indianapolis (1954-1958); Jack Munsee, Bloomington (1955-1959); Ernest Litweiler, South Bend (1956-1960).

PROGRAM OF THE TWENTY-FOURTH ANNUAL MEETING

OCTOBER 13, 1956

Room 124, Jordan Hall, Indiana University, Bloomington, Indiana.

8:30-9:30 a. m. Registration and Placement of Exhibits, Room 129, 031, Jordan Hall.

9:30-10:30 a. m. General assembly on careers in mathematics and science by faculty representatives of Indiana University, Jordan Hall.

10:30-11:00 a. m. Visits to campus instructional and research laboratories.

11:15 a. m.-12.30 p. m. Luncheon, Union cafeteria.

1:00-2:00 p. m. Business meeting and election of officers. Room 124, Jordan Hall.

2:00-4:00 p. m. The Assembly Program. Room 124, Jordan Hall.

Papers: Roger Cuffey, presiding.

1. *Embedding Insects in Plastic* (illustrated). Don Lee, Junior Academy of Science, South Side High School, Fort Wayne.
2. *Adapting a Television Set to Short-Wave Reception.* Joseph Conrey, Phy-Chem Club, Our Lady of Providence High School, Clarksville.
3. *My Mineral Collection.* William Forgey, Biology Club, Lew Wallace High School, Gary.
4. *An Automatic Wilson Cloud Chamber.* Brett Nordgren, Central Junior Academy of Science, Central Junior-Senior High School, South Bend.
5. *A Diet Study of the Long-Eared and Saw-Whet Owls* (illustrated). Betty Jane Gough, New Castle High School, New Castle.
6. *Extraction of 17-Keto Steroids from Urine.* King Hunter, Science Club, Howe High School, Indianapolis.
7. *Effects of Toothpaste on Mouth Bacteria.* Hugh Osborne, Science Club, Howe High School, Indianapolis.
8. *Antibiotic Assays with Actinomyces.* Ronnie Heath, Science Club, Howe High School, Indianapolis.
9. *Regeneration of the Planaria* (illustrated). Illah Mae Reeves, Adams Walton Club, Adams High School, South Bend.
10. *TV D-xing.* Milton D. Cox, Nature Study Club, Arsenal Technical High School, Indianapolis.
11. *Carcinogenically Induced Cancer in Mice.* Julia Freeman, Science Club, Howe High School, Indianapolis.
12. *Study of the Paramecia.* Jim Lucas, Science Club, Howe High School, Indianapolis.
13. *Mars.* Roger Cuffey, Junior Academy of Science, University High School, Bloomington.
14. *Remote Control Wiring.* Suzanne Hess and Faris Kenney, Phy-Chem Club, Our Lady of Providence High School, Clarksville.

MINUTES

The twenty-fourth annual meeting of the Indiana Junior Academy of Science was held Saturday, October 13, 1956 in the auditorium of Jordan Hall, Indiana University, Bloomington, Indiana.

A total of fourteen science projects and exhibits by high school students were displayed in room 129 of Jordan Hall beginning at 8:30 a. m. The outstanding exhibits included a vacuum bailer, a television set adapted to short-wave reception, a mineral collection, a demonstration study of paramecia, an insect collection embedded in plastic, an automatic Wilson cloud chamber, a model showing remote control wiring, a flat cathode-ray tube, and a demonstration of TV D-xing.

A general assembly was held in the auditorium from 9:30-10:40 a. m., after which conferences in science and mathematics were conducted by members of the faculty of Indiana University. Faculty representatives of the University met with students according to their interests in anthropology, astronomy, bacteriology, botany, chemistry, geology, mathematics, physics, psychology, and zoology. The members of the Junior Academy appreciated the efforts of the University staff in offering such a wide range of scientific areas for discussion.

Following at 10:30, guided tours to the instructional and research laboratories of Indiana University were conducted by faculty members.

The annual business meeting was called to order at 1:00 p. m. in the auditorium of Jordan Hall with president, Roger Cuffey presiding.

The president introduced the other officers, vice-president, Brett Nordgren, Junior Izaak Walton Science Club, Central High School, South Bend, and secretary, Paula Erpelding, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne.

The minutes of the 1955 meeting were reviewed by the secretary.

Professor R. W. Lefler, Purdue University, chairman of the Indiana Science Talent Search committee explained the procedure for entering the Science Talent Search. In reviewing the history of the Science Talent Search, he stated that 119 of the students from Indiana who entered the contest last year are now in college. 62 of these were awarded scholarships.

He also called attention to the fact that nine regional science fairs are scheduled for 1957 at the following colleges: Valparaiso University; Goshen College; Purdue University Center, Fort Wayne; Purdue University; DePauw University; Indiana University Medical Center, Indianapolis; Earlham College; Indiana University; Evansville College.

Professor Lefler explained that two finalists were chosen from the senior division of each regional fair, who will be awarded an all expense paid trip to the National Science Fair to be held in San Francisco in May of 1957.

Professor Lefler closed his talk with the following encouraging words: "Good luck! Hard work always pays great dividends in the end."

The next item of the business meeting was the election of officers. A list of nominees was submitted by the council and additional nominations were accepted from the floor. The following officers were elected to carry on the activities of the Junior Academy during 1957: president,

Betty Jane Gough, Science Club, New Castle High School, New Castle; vice-president, Wilfred Day, Phy-Chem Club, Our Lady of Providence High School, Clarksville; secretary, Margaret Reynolds, Science Club, Washington High School, Indianapolis.

The Junior Academy Council reported the selection of Mrs. Elizabeth H. Crider, science teacher, Washington High School, Indianapolis, as the new council member to replace Mr. Charles E. Karst, Mishawaka, whose term expired. Each council member serves a term of five years.

Donald Lee, South Side High School, Fort Wayne, opened the program of papers with an illustration of the step by step process of embedding insects in plastics.

Joseph Conrey, Phy-Chem Club, Our Lady of Providence High School, Clarksville, whose paper was titled, "Adapting a Television Set to Short Wave Reception," showed how he converted his own TV set into a short wave receiver.

A large mineral collection, consisting of rocks from all over the world was exhibited by William Forgey, Biology Club, Lew Wallace High School, Gary. His most outstanding specimens included gold ore, silver ore, white gold and a very interesting stalagmite.

Brett Nordgren, Junior Izaak Walton Club, Central High School, South Bend, with the assistance of Dick Dunbar, demonstrated his Automatic Wilson Cloud Chamber. He explained that since he couldn't obtain one for use in his project, he built his own.

With the use of kodachrome slides, Betty Jane Gough illustrated a diet study of Long-eared and Saw-whet owls.

Extraction of 17-Keto Steroids from Urine was the topic presented by King Hunter, Science Club, Howe High School, Indianapolis. He reviewed the step by step process in the preparation of Keto steroids.

A very interesting and amusing account of the effects of toothpaste on mouth bacteria was submitted by Hugh Osborne, Science Club, Howe High School, Indianapolis.

Also representing Howe High School was Ronnie Heath, whose paper was entitled, "Antibiotic Assays with Actinomyces."

Illah Mae Reeve, Adams Walton Club, Howe High School, Indianapolis, illustrated results calculated from her experiments on the regeneration of the planaria. As a result she concluded that the anterior end regenerated more quickly and produced healthier planaria.

A chart consisting of a map surrounded by photographs, expressing phenomenal TV reception, was used by Milton Cox, Nature Study Club, Arsenal Technical High, Indianapolis, in presenting his paper, TV D-xing.

Julia Freeman, Science Club, Howe High School, Indianapolis, showed the results of carcinogenically induced cancer in mice. Her monthly calculated observations showed the rapid growth of cancer.

Study of the paramecia was the next subject submitted by Jim Lucas, Howe High School, Indianapolis.

The next talk given by Roger Cuffey, University High School, Bloomington, whose project dealt with Mars, was highlighted by a slide which showed the trends of the dust paths of Mars.

The concluding topic was Remote Control Wiring, which was studied and explained by Suzanne Hess and Faris Kenney, Phy-Chem Club, Our Lady of Providence High School, Clarksville. They sketched and compared on the board the Westinghouse model and the Remcon model.

Miss Jerry Motley announced that the "Best Boy" award for 1957 would go to Brett Nordgren, Izaak Walton Club, Central High School, South Bend, and that the "Best Girl" award for 1957 to Betty Jane Gough, Science Club, New Castle High School, New Castle.

The winners of these awards are chosen by the Junior Academy Council on the basis of information submitted by science club sponsors and a personal interview with the student. The recipients of the award are given a year's membership in the American Association for the Advancement of Science and will receive its monthly publication, "The Scientific Monthly."

Those receiving honorable mention awards were Illah Mae Reeve, Adams High School, South Bend, Roger Cuffey, University High School, Bloomington, and King Hunter, Howe High School, Indianapolis.

Forty-seven high school science clubs are affiliated with the Junior Academy of Science. This year we gained two new members: Phy-Chem Club, Our Lady of Providence High School, Clarksville; Junior Academy, South Side High School, Fort Wayne.

The Junior Academy will meet at DePauw University in the Fall of 1957. The president urged all club members and sponsors to participate by preparing papers and exhibits.

After expressing his appreciation to Indiana University, to all who participated and to those who attended, the president, Roger Cuffey, adjourned the meeting.

PAULA ERPELDING,
Secretary

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS

FALL 1956

	Town	*School and Club*	*Sponsor*
1.	Attica	H. S., Sci-Math (1949)	J. Claude Daugherty
2.	Bedford	H. S., Science (1951)	Elmer Wright
3.	Bloomington	H. S., National Scientific Honor Society (1931)	Harold A. Stewart
4.	Bloomington	University H. S., Jr. Academy (1938)	Jack Munsee
5.	Chesterton	H. S., Science (1954)	Robert McCord
6.	Clarksville	Our Lady of Providence H. S., Phy-Chem (1956)	Sister Mary Blanche
7.	Clayton	H. S., Jr. Academy (1951)	Howard C. Lewis
8.	Crawfordsville	H. S., Up-N-Atom (1950)	David Wells
9.	Edinburg	H. S., The Alchemists (1954)	S. C. Harrell
10.	Elkhart	H. S., Jr. Academy (1940)	Mrs. Evelyn Wagoner Miller

	Town	*School and Club*	*Sponsor*
11.	Fort Wayne	Central H. S., Biology (1940)	Iva Spangler
12.	Fort Wayne	Central Catholic H. S., Albertus Magnus Science Club (1952)	Sr. Mary Agnita S. P.
13.	Fort Wayne	Elmhurst H. S., Phy-Chem (1935)	Ruth Wimmer
14.	Fort Wayne	North Side H. S., Nature (1936)	Vesta Thompson
15.	Fort Wayne	Jr. Academy of Science, South Side H. S. (1956)	Don Weaver Robert Weber
16.	Gary	Calumet Twp., H. S., Science (1952)	
17.	Gary	Edison H. S., Beaker Breakers (1949)	Mrs. Martha B. Connor
18.	Gary	Lew Wallace H. S., Biology (1935)	Lola Lemon
19.	Gary	Lew Wallace H. S., Klub Kem (1941)	Mrs. Helen McKenzie
20.	Gary	Tolleston H. S., Biology (1952)	Edith Wallace
21.	Gary	Tolleston H. S., Future Scientists of America (1949)	Arthur Kline
22.	Gary	Wirt H. S., Biology (1945)	Mrs. Frances Huddleston
23.	Gas City	Mississinewa Joint H. S., Science (1936)	Roy McKee
24.	Griffith	H. S., Science (1953)	George M. Bunce
25.	Hamlet	H. S., Science (1954)	Lawrence Cushman
26.	Hammond	Morton Jr. H. S., Science (1949)	Nancy Lou Ritter
27.	Highland	Science (1956)	
28.	Hobart	H. S., Science (1952)	Lola Stewart
29.	Indianapolis	Shortridge H. S., Naturalist's Club (1947)	Max Forsyth
30.	Indianapolis	Shortridge H. S., Science (1931)	Mrs. Henrietta A. Parker
31.	Indianapolis	Technical H. S., Nature (1932)	Mrs. Joan Persell C. F. Cox
32.	Indianapolis	Howe H. S., Science (1949)	Jerry Motley
33.	Indianapolis	Washington H. S., Science (1931)	Mrs. Elizabeth H. Crider
34.	Lebanon	H. S., Jr. Explorers of Science (1953)	Helen E. Reed
35.	Marion	Martin Boots Jr. H. S., Biology (1953)	John Clevenger
36.	Mishawaka	H. S., Science (1936)	Darl F. Wood

	Town	*School and Club*	*Sponsor*
37.	New Albany	H. S., Science (1935)	L. S. Rose
38.	New Castle	H. S., Science (1947)	Mrs. Mary Gough Robert Rinehart
39.	New Haven	H. S., Phi-Chi (1954)	Keith Hunnings
40.	Richmond	H. S., Science (1950)	Kathryn Coulter
41.	Rossville	H. S., Science (1954)	John M. Kramer
42.	Sandborn	H. S., Up and Atom (1954)	Paul D. Carter
43.	South Bend	Central H. S., Jr. Izaak Walton (1939)	A. L. Smith V. C. Cripe
44.	South Bend	John Adams H. S., Adams Walton (1953)	Ernest Litweiler
45.	Sullivan	H. S., Camera (1939)	Ruth Hinkle
46.	Terre Haute	State H. S., Senior Science (1939)	Russell McDougal
47.	Valparaiso	H. S., Science (1931)	Gerald Doeden

NECROLOGY

O. B. CHRISTY, Muncie

ALBERT REIFF BECHTEL

Royersford, Pennsylvania	Indianapolis, Indiana
March 21, 1882	December 11, 1955

Dr. Albert Reiff Bechtel, one of the distinguished botanists of Indiana, was born March 21, 1882 in the small town of Royersford, Pennsylvania and died at the home of his son in Indianapolis, December 11, 1955.

Dr. Bechtel began teaching after leaving high school and continued until he was able to enter the University of Pennsylvania. He graduated from this institution with both B.S. and M.A. degrees in 1912. Following graduation he taught botany at Pennsylvania State College for two years. Here he met and married Lenore Barton, a Swarthmore graduate. Two sons and one daughter were born to the Bechtels. They constituted a very happy and devoted family.

From 1914 to 1920 he was a graduate student and instructor in Cornell University. While there he obtained his doctorate in 1920. He came to Wabash College in September of that year as head of the department of botany and remained there until his retirement in 1951. His abilities and his admirable personality made him a beloved teacher and honored citizen of his college and community.

Dr. and Mrs. Bechtel were members of the Wabash Avenue Presbyterian Church where they gave much of their time and ability. He was for many years an elder and superintendent of Sunday School.

Soon after Dr. Bechtel came to Wabash College, he became a member of the Indiana Academy of Science. He was made a Fellow in 1933 and served as vice-president in 1947. He refused the presidency. The Proceedings include two of his papers, "Rare Gastromycetis," Vol. 44, and "Teaching Bacteriology," Vol. 49.

Dr. Bechtel held membership in the American Association for the Advancement of Science. He was an associate in the Society of Taxonomists, the Botanical Society, and the Mycology Society.

Dean Kendall of Wabash College was closely associated with him and had the opportunity to know his abilities as a teacher, scientist, and a citizen.

No more fitting tribute can be given to Dr. Bechtel than to quote from Dean George V. Kendall's eulogy given on the occasion of a memorial service held in the chapel at Wabash College, Friday, December 19, 1955. To quote Dean Kendall—"The list is long of capable men whom he (Bechtel) lighted with enthusiasm for plants and sent on to courses in botany. But the list is much longer of men who took one course with him as a requirement and no more, and who carried with them into all walks of life a respect for accurate observation and reverence for the ways of Nature.

"The very fine herbarium of Wabash College has his name or the name of Professor Coulter on the largest number of sheets. His delight in the trees and small vegetation of our campus was inexhaustible.

"Great as his direct service to the college was, however, his value as a citizen—as a man—will be, I think, as long or longer remembered. There are alumni of the Presbyterian Sunday School, graduated Boy Scouts, and club members without number in the community and elsewhere in Indiana, who will not forget the insights he gave them into nature nor the modesty, gentleness, and courtesy with which he always encountered his fellow men."

MR. WILLIAM LOWE BRYAN

Monroe County, Indiana	Bloomington, Indiana
November 11, 1860	November 21, 1955

In the death of William Lowe Bryan, this Academy, the state of Indiana, and the Nation suffered a heavy loss. His attainments as an educator, scientist, teacher, philosopher, and administrator brought him universal respect and affection.

The continuing influence of this great personality is clearly pictured in the events and varied interests of his life. He was born in the county in which we are now assembled, November 11, 1860. In this county of Monroe, Indiana, he received much of his education, found his life mate, the gracious Charlotte Lowe, and carried on his long life work.

He died November 21, 1955, ten days after his 95th birthday, in the President's House on the campus of his beloved Indiana University. He was buried in Crown Hill Cemetery of our Hoosier Capital. Here he rests with Mrs. Bryan and with many of the country's notables, including one president, three vice-presidents, authors, senators, governors, and his beloved friend, James Whitcomb Riley.

It is interesting to note that Dr. Bryan at the age of 92, three years before his death, handed to President Herman B Wells a statement to be used, so he said, "when the time comes." This modest statement interprets for us certain good fortunes which came to Dr. Bryan and influenced his life. These were read by President Wells at the funeral services of Dr. Bryan, November 23, 1955, after which he paid great tribute to his beloved predecessor.

In this autobiographical statement, Dr. Bryan pays great tribute to his parents who gave him a life capable of health, ambition, and longevity. They provided him with the necessities and many comforts. He was brought up through infancy and youth with wisdom, kindness, and firmness. He considered it his good fortune to have lived on a farm and near a college town. The best part of his early education was in his home where good English was spoken and many books were at hand. The Bible was read in a service of worship every morning and evening.

Dr. Bryan became a teacher in the Bloomington Schools in 1884. One year later, David Starr Jordan, the newly elected President of Indiana University offered young William a position on the faculty as instructor. This marked the beginning of a long and intimate friendship of two great men. Later, Dr. Bryan twice refused to accept a position, under President Jordan, at Leland Stanford University.

It was under the inspiring influence of President Jordan that Dr. Bryan became a student of psychology which took him to Berlin and Clark University for further graduate work. He returned to Indiana to continue his teaching of psychology and his pioneering experimental work in the subject.

He made a study of the occupations of the graduates of Indiana University which covered the period of 1830 to 1900. He discovered that during the early part of the period most of the graduates became doctors, lawyers, or preachers, but almost no teachers. During the latter part of the period, great numbers of the graduates became teachers. He feared the school was ceasing to be a university and was becoming a normal school.

Dr. Bryant had just finished this study in 1902 when he became President of the University. He set about at once to reorganize the institution by establishing a central core of liberal arts studies surrounded by a number of professional schools and thus fulfill what had always been the ideal of the school.

Practically the entire life of Dr. Bryant was spent in the shadow of Indiana University and some 70 of his years were spent as a student, teacher, vice-president, president, or president emeritus. During the 35 years in which he served as president, the university made a tremendous growth. At the beginning of his administration, it was a college of nine buildings with teaching emphasis devoted almost entirely to the arts, sciences, law, and the classics. When he retired, the university had 27 buildings on the Bloomington campus and nine in Indianapolis. Many other changes were made such as the addition of the School of Medicine, a Graduate School, the School of Education, the Extension Division, the Training School for Nurses, the School of Commerce and Finance, the School of Music, and the School of Dentistry. Under his administration other expansions took place including the further development of the James Whitcomb Riley Hospital, the Robert W. Long Hospital, and the Coleman Hospital—all a part of the Medical Center at Indianapolis.

During the long and busy life of Dr. Bryan, he was always able to find time to express his thoughts in writing. These were always carefully written and expressed in simple and excellent language. He was the author of several books and many articles. He wrote a series of volumes about Plato with Mrs. Bryan as co-author. He was also a very effective speaker. His words of wisdom and philosophy were in great demand by educational groups.

The great contribution which Dr. Bryan has made to public education is understood and appreciated throughout the nation. He believed in education for the masses and worked constantly for the development of the public schools. He served as president of the Indiana State Teachers Association. He became known as the "Grand Old Man of Education" and was often referred to as "Mr. Indiana in Education." Dr. Bryan joined the Academy of Science in 1893, and remained a member until he died in 1955,—a record probably not equaled by any other member. He was made a Fellow in 1914. He presented a number of papers before the Academy from the experimental work he did in his chosen field of psychology.

Dr. Bryan established at Indiana University in 1888 the second psychological laboratory in America. Here he began his extensive study of the learning processes. From these studies, he worked out the first "curve of learning" ever to be developed. These studies showed learning processes move first at a rapid rate then later at a slower rate. He also demonstrated the "plateaus of learning" which have been used so generally in text books on psychology. These studies were regarded as classic, and gained world wide recognition for him.

In the passing of the "Grand Old Man" of education, Indiana loses one of its most distinguished scholars, a keen philosopher, a noted scientist, a great administrator, a forceful speaker, and above all a great teacher. His influence has reached into all parts of the nation and his achievements symbolize opportunity in America at its best.

ALFRED C. KINSEY

Hoboken, New Jersey	Bloomington, Indiana
June 23, 1894	August 25, 1956

Dr. Alfred C. Kinsey, professor of zoology at Indiana University, author, lecturer, authority on the gall wasp, and internationally known for his study of human sex relations was born in Hoboken, New Jersey on June 23, 1894. He died in Bloomington, Indiana, August 25, 1956. He was the son of an engineering professor.

Much of his first ten years was spent in bed beset with rickets, heart trouble, and finally typhoid fever. His parents moved to South Orange where his health improved. He spoke of his new environment as follows: "It was amazing to me that there were flowers to be had for the picking and there were birds more brilliantly colored than house sparrows." His father gave him a book on flowers which started his passionate curiosity about nature. Soon he was engaged in a research project. He wrote his first publication on "What Birds Do in the Rain," which appeared in a nature journal while young Alfred was still in the grades. He studied piano at the age of five and in college he loved to play Beethoven and Chopin for his fraternity brothers. He graduated from South Orange High School at the age of 16 with high honors.

He led nature hikes at summer camps and he tutored. This helped him to pay his way through Bowdoin College. He received his A.B. degree from Bowdoin in 1916 with a major in biology and zoology. He received his Sc.D. in 1920 from Harvard University with a major in zoology. While at Harvard he studied wild food plants and became an expert in this subject. He wrote a book with the late Merritt Lyndon Ferald on "Edible Wild Plants of Eastern North America." At Harvard Dr. Kinsey began his research on insect life; this he continued after coming to Indiana University and it culminated in his famed report on the gall wasp. This work has been published in two volumes and has added much to the knowledge of genetics and evolution. His data for this monumental work were obtained from a careful study of 28 factors of 150,000 specimens.

Soon after coming to Indiana, Dr. Kinsey became convinced that the high schools were in need of a biology text, which students could study with more interest and which at the same time, presented the necessary fundamental principles. He set about to write such a text and the result was his noted "An Introduction to Biology." This text was written and illustrated in a manner which appealed to students. This book with its revisions and its accompanying "Workbook in Biology" met with a hearty response and was widely adopted throughout the country.

However, world wide recognition of Dr. Kinsey came through the publications of "Sexual Behavior of the Human Male" in 1945 and "Sexual Behavior of the Human Female" in 1953. According to President Herman B Wells, President of Indiana University, the sale of these two books have run into the hundreds of thousands and they have been published in a dozen different languages. They may be considered as pioneer studies of great significance.

Dr. Kinsey had laid out a schedule of future work to continue his study of sex which would require many years to complete and result in the publishing of several volumes.

He joined the Indiana Academy of Science in 1920 and was made a Fellow in 1927. He appeared on several Academy programs and had two papers published in the Proceedings. The first "Biological Sciences in Our High Schools" which appears in Volume 35. The second "New Mexican Gall Wasps" appears in Volume 47. In addition to these two papers he has an abstract in Volume 35—"The First Results of the Indiana University Mexican Expedition."

We are perhaps too close to Dr. Kinsey's day to make a fair appraisal of his place in history and in science. However, he always will rank among the great and is one of the most widely known personalities of our times.

DR. SAYERS J. MILLER

Indianapolis, Indiana	West Lafayette, Indiana
July 30, 1898	December 18, 1955

Dr. Sayers J. Miller, director of Purdue University Health Service, died at his home in West Lafayette, Indiana, December 18, 1955. His death ended a remarkable career of service to Purdue and to thousands of his students over a period of 29 years as a member of the health staff.

Born in Indianapolis, July 30, 1898, Dr. Miller was graduated from the Manual Training High School and attended Butler University before enrolling in the Indiana University School of Medicine, from which he graduated in 1924. Two years later, he joined the Purdue Medical staff and became its director in 1935, a position held until his untimely death.

During the long period of service which Dr. Miller gave to the University, he became one of the most beloved members of the faculty and endeared himself to thousands of students who visited the health service every year. His figure became familiar to thousands of spectators who attended the Purdue athletic events. He was always on the sidelines ready to care for the Boilermakers. He was truly their guardian of health.

During World War II, Dr. Miller, as medical director, filled a unique place in the lives of Purdue students. It was his responsibility to examine and treat the thousands of students in the various programs on the campus. This assignment was so well done that no major epidemic occurred. For this excellent record, he was cited by various official organizations.

Dr. Miller was affiliated with many civic, fraternal, church, and professional organizations. He was a member of the Methodist Church, the Kiwanis Club, Masonic groups, Indiana Medical Association, American Legion, Public Health Association, and the American Medical Association. He became a member of the Indiana Academy of Science in 1926. With his many duties and varied interests it would have been difficult for him to have attended the meetings of the Academy or to have been an active member, but it is enough to say that Dr. Miller has made a valuable contribution toward the betterment of mankind and all revere the high principles for which he stood.

The lofty esteem which the students, faculty, and alumni of Purdue held for this worthy character was manifest in the founding of a Sayers J. Miller Scholarship Fund that was started immediately after his death.

BERT R. MULL

Putnam County, Ohio — Monticello, Indiana
July 2, 1890 — January 31, 1956

Dr. Bert R. Mull passed away at his home at Monticello, Indiana, January 31, 1956. He was primarily a pharmacist. He spent many years of his early life in various drug stores as clerk, partner, manager, and owner.

He was born July 2, 1890 in Putnam County, Ohio. He graduated from high school in Continental, Ohio in 1905 and attended Ohio Northern University. This institution conferred upon him an honorary doctorate in pharmacy administration in 1952.

Dr. Mull joined Eli Lilly and Company in 1927, as the Columbus, Ohio representative. After one year, he was transferred to Indianapolis to the advertising department of the company. Later, he became manager of the trade relations department and was active in the advertising functions of the company. This position he held for many years. He was director of special assignments in marketing which he held at the time of his retirement from the company in 1955. He was associated with Eli Lilly Company for 28 years.

Dr. Mull was associated with Butler University as professor of pharmacy administration and taught classes in the school of pharmacy. He was holding this position at the time of his death.

He was a forceful speaker and often represented Eli Lilly Co. at conventions and pharmaceutical meetings. He organized and served as moderator of the All American Pharmacy Seminar, which appeared on drug programs from coast to coast.

Dr. Mull belonged to a number of organizations representing various phases of his chosen field. He was long active in the American Pharmaceutical Association serving as chairman of the House of Delegates, public relations committee, and section of pharmaceutical economics. He was a member of the National Association of Retail Druggists and the American Society of Hospital Pharmacists.

He joined the Indiana Academy of Science in 1951. We regret that the brief time he was a member of the Academy was too short for many of us to know him personally. However, we join with his many friends and associates in expressing appreciation for the devoted service he rendered to humanity through his chosen field. Dr. Mull is survived by his widow, the former Lena E. Biglow and a daughter, Mrs. Ray A. Houghton of Indianapolis.

WILLIAM MOTIER TUCKER

Holton, Indiana	Fresno, California
November 18, 1877	October 12, 1955

William Motier Tucker, long a member of this Academy, was born in Ripley County, Indiana, near Holton, November 18, 1877. He received his early education in that community. He became a farmer and then a teacher.

While a student in the Holton non-commissioned high school and the Ripley County Normal School he came in contact with three excellent and inspiring teachers who, according to young William, aroused his ambition to become a teacher.

After teaching for one term in a one room rural school near his home he entered the Indiana State Normal School in 1900 and graduated in 1905. During this time he taught three terms in his native county and the following year he taught eighth grade in Goodland, Newton County, Indiana.

While a student in Indiana State Normal School he was laboratory assistant in physical geography for Dr. Charles R. Dryer. It was my good fortune to be a student in one of these laboratory sections. I remember well my admiration for the young Mr. Tucker, who taught us how to identify the common rocks, and the location of the chief physical features of the North American Continent. We had great respect for our young instructor. We learned with interest that there were many kinds of rocks—each with its own characteristics and history. It was reported among members of the class that he knew so much about rocks because they had been his hobby since boyhood.

Mr. Tucker's experience with Dr. Dryer was no doubt, a guiding influence in helping to direct him to enter Indiana University and to choose geology for his major work. He received his A.B. from Indiana University in 1908, his A.M. in 1909 and his Ph.D. in 1916.

After teaching science in several high schools of Indiana and California, Dr. Tucker taught physical geography in Moorehead, Minnesota State Teachers College from 1913 to 1915. He then joined the faculty of the University of Texas and later Ohio State University. In 1920 he joined the geology staff at Indiana University. This position he held from 1920-1927 until he was appointed head of the Geography and Geology Department at Fresno State Teachers College at Fresno, California. This position was held until his retirement in 1942. He remained in Fresno until his death October 12, 1955. He married Truly B. Ray of Bloomington in 1916, a few days after he received his doctorate. Mrs. Tucker passed on in 1935.

Dr. Tucker was a member of the Gimbel Expositions to British Guiana in 1910. He was appointed State Hydrologist of Indiana in 1920 and served until 1927. Among his publications were Hydrology of Indiana, Pyrite Deposits in Ohio Coals; and Tertiary Volcanic Activity in the Valley of the San Joaquin River.

He became a member of the Indiana Academy in 1910, and was elected a Fellow in 1923. He appeared on the Academy program many times and had four papers published in the Proceedings. It is a fine tribute to this Academy that a man of the ability of Dr. William M. Tucker would become a member and retain his membership for nearly a half century when much of the time he was unable to attend the meetings because of his residence in other states. His memory will be cherished long by those of us who knew him.

PRESIDENTIAL ADDRESS

THE CAPTURE AND USE OF SUNLIGHT

RAYMOND E. GIRTON, Purdue University

Introduction

Without sunlight life on earth, at least as we know it, would cease to exist. In fact, life could not have originated in the absence of sunlight, or of some comparable form of energy. What then is the nature of sunlight, how does it originate, and how is it caught and used on earth? These and related questions are the subjects of this discussion.

Taking the term "sunlight" in its broadest sense we may include not only the visible solar radiations (390-760 $m\mu$) which are perceived by the eye but also those shorter ultraviolet radiations (300-390 $m\mu$) which penetrate our atmosphere, plus additional wave lengths longer than the visible radiation. These longer wave lengths represent the infrared or heat rays and, as received at the earth's surface from the sun, range from 760 to approximately 2600 $m\mu$. The unit "$m\mu$" (millimicron) is equal to one thousandth of one millionth of a meter and is the diameter of the smallest colloidal particles.

In addition to the wave concept of sunlight, there is also the corpuscular concept which pictures discrete particles or "photons" of light, each photon containing one packet of energy, the "quantum." These quanta are of various sizes, those of the shorter wave lengths such as the blue, violet, and ultraviolet are considerably larger than the quanta of the longer wave lengths, particular the red and infrared (fig. 1).

The intensity of the radiant energy received from the sun, when expressed as amount received per unit area per unit time, is termed "irradiance" and may be measured in g.-cal. per $cm.^2$ per min. (1). "Brightness" on the other hand refers to the strength of illumination as perceived by the human eye and is commonly expressed as foot-candles or as meter-candles. Maximum sunlight intensities at the earth's surface in midtemperate zones occur at midday in summer and are on the order of 1.2 to 1.5 g.-cal. per $cm.^2$ per min.—this latter amount of energy falling on 1 sq. ft. of surface is sufficient to raise the temperature of one quart of water 2.5 Fahrenheit degrees in one minute. These maximum irradiance values correspond approximately to brightness values of 8,000 to 10,000 foot-candles (fig. 2) (2).

Another important feature of sunlight is that of "duration" or length of day. In the midtemperate zones, hours of sunshine per day may vary from 9 for December to 15 for June. Obviously much less seasonal variation is found as equatorial latitudes are approached where daylengths are maintained near 12 hours. On the other hand considerably more variation occurs at higher latitudes (fig. 3).

Fig. 1

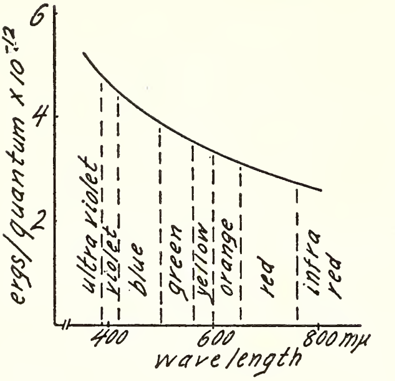


Fig. 2

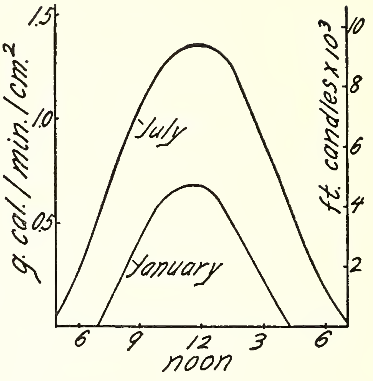


Fig. 3

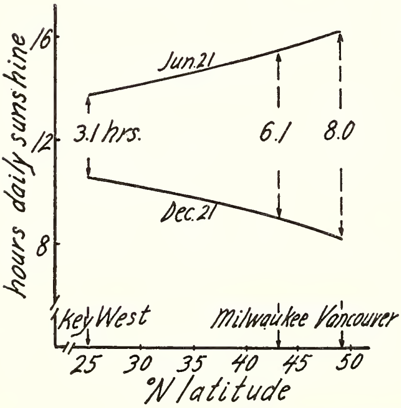


Fig. 4

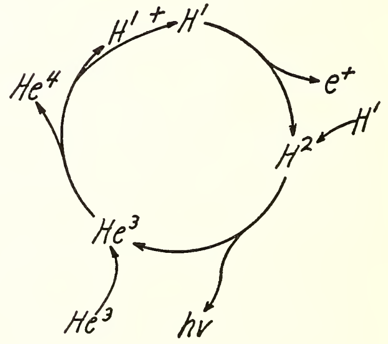


Fig. 1. Wave length and quantum size of visible light and adjoining regions.

Fig. 2. Diurnal sunlight curves for July and January at 40° N. latitude. After Meyer and Anderson (2).

Fig. 3. Effect of latitude upon maximum and minimum day lengths. Data from Meyer and Anderson (2).

Fig. 4. Radiant energy (hν) release through H^2-He^3 pathway.

Modern theory (3) concerning the origin of sunlight pictures the sun as a huge mass of broken atoms, atomic nuclei, and electrons at temperatures ranging from 6,000° C at the surface to 26,000,000° C in the interior. At these inconceivably high temperatures reactions take place between various atomic nuclei which result in the release of tremendous quantities of energy. Thus, collisions of hydrogen and carbon nuclei may lead to a cycle involving nuclei of N^{13}, C^{13}, N^{14}, N^{15}, C^{12}, and additional hydrogen nuclei to release electrically charged positrons, helium nuclei, and radiant energy. Or collisions of hydrogen nuclei may pass through a H^2-He^3 nuclear pathway to form the stable He^4 nucleus, positrons, and again releasing radiant energy (fig. 4). It is this radiant energy which showers the earth with life-giving sunlight. Calculations indicate that such conversions of hydrogen to helium equivalent to one percent of the sun's mass are sufficient to supply one billion years of sunlight.

Life's Coming Into Being

Perhaps two billion years ago, so we are told (4), no life existed on the earth. The atmosphere may have been more or less completely devoid of oxygen but rich in methane, carbon monoxide, ammonia, cyanogen, and water vapor, with probably some hydrogen in addition. The sea was, in the words of J. B. S. Haldane (5), "a hot dilute soup." The sun bathed the globe with energy-filled light. Somehow, from this brilliant sunlight and the ingredients of that "hot dilute soup" life was gradually to emerge.

Very early nineteenth-century chemistry categorized organic compounds as substances which could be synthesized only by living organisms. However, in 1828 the German chemist Wöhler (6) synthesized urea from potassium cyanate and ammonium sulfate thus disproving the concept that organic compounds can arise only within living matter. The laboratory synthesis of countless other organic compounds since this beginning made by Wöhler has proved conclusively that organic synthesis is not the exclusive property of living organisms. It thus appears reasonable that the synthesis of organic compounds could have, in some former geologic period, preceded the existence of living organisms.

The phenomen of abiogenesis or spontaneous generation, that is the formation of living organisms from nonliving matter, has never been observed, however. In fact the great French biologist of the 19th century, Louis Pasteur, was able to show that such a process as fermentation takes place only in the presence of living microorganisms and that when all life was killed by heat no new organisms and no renewed fermentation arose as long as the fermentation medium was protected from contamination. Other early workers, Redi for example, disproved the then current belief that maggots arose spontaneously from meat by the simple expedient of protecting the meat from egg-laying flies. How then is it reasonable to consider that living matter could ever have arisen from nonliving material?

At least two suggestions have been given which have a bearing upon this question (7). The first suggestion is that the change from nonliving to living matter is at best a very slow process so that the limited observational times in controlled studies of possible abiogenesis are far too short to permit the development of recognizable living forms. Moreover, in today's natural environments the formation of even rudimentary microscopic living forms would not be expected to occur because of the multitude of living organisms already present in the sea and elsewhere where life might originate. These organisms are continually searching for and taking in food, and would thus consume precursory substances from which living matter might be formed. In contrast, initial pre-biological abiogenesis could have continued uninterruptedly over long periods of time since at that time no life was present on the earth and therefore early precursory substances would not have been used up as a food.

A second suggestion in favor of pre-biological abiogenesis lies in the probable different composition of the earth's atmosphere during early times (8). Evidence, including reduction-oxidation potential studies, points to a lack of oxygen in the earth's atmosphere at the time life originated. This would mean a corresponding absence of the ozone screen now normal to the atmosphere, a screen which is instrumental in absorbing much of the sun's ultraviolet radiation. Thus a more effective form of radiation would have reached the earth's surface—a radiation having photons with larger quanta and with wave lengths more actively absorbed by chemical reactants in preliving systems.

A contempory view of the initiation of life on this earth, therefore, is one which envisages photochemical reactions which utilized energy from the then ultraviolet-rich sunlight, together with appropriate catalytic systems. The well known role of the adenosine phosphates in storing, transforming and mobilizing energy in the metabolism of living organisms is suggestive of the probable great importance of phosphorous in energy transfers also in preliving systems. If life originated in an oxygen-impoverished environment, as is conjectured, less highly oxidized forms than the phosphates—such as the phosphites and hypophosphites—would have had the advantage of greater solubilities and greater reduction—oxidation potentials, both of which would act to increase the effectiveness of phosphorous in energy transfer systems. According to Gulick, suggested beginnings of organic synthesis in an atmosphere containing methane, ammonia, carbon monoxide, hydrogen, and water vapor, and promoted by photochemical energy include the formation of carbon-carbon bondings in compounds such as ethane ($H_3C—CH_3$), ethylene ($H_2C{=}CH_2$), and acetylene ($HC{\equiv}CH$). Hydrocarbon- and ammonia-addition products then could form amines, such as ethylene amine ($CH{\equiv}CH + NH_3 \rightarrow CH_2{=}CH—NH_2$). Other suggested reactions include the formation of cyanamide from carbon monoxide and ammonia ($CO + 2NH_3 \rightarrow NH_4OC{\equiv}N + H_2 \rightarrow \underset{\text{cyanamide}}{H_2NC{\equiv}N} + H_2O + H_2$). Additional syntheses of nitrogenous compounds involve the reaction of cyanamide with ammonium phosphite to form guanidine phosphite which in turn can go to phosphoguanidine, a high-energy phosphocompound. Further syntheses are thought to have led to the formation of complex macromolecules of proteins containing nucleic acid. Such proteins as found in viruses and genes have the property of growth and self-duplication. At some such stage rudimentary living organisms may have originated.

The Use of Sunlight by Green Plants

The green plant is nature's number one converter of the energy of sunlight into stored and useful forms. Photosynthesis on earth is accredited (9) with using approximately 400 billion tons of CO_2 annually in the production of 300— billion tons of photosynthate. Contrast these figures with the huge steel industry which on a world basis produces annually some 100 million tons of steel. Photosynthesis is thus some 3,000 times greater in magnitude than is the production of steel. It is of interest to note that most of the global photosynthesis is believed to occur in the oceans, perhaps nine-tenths of the total as compared with one-tenth on land. This is explained on the basis of three-fourths of the surface of the earth being composed of water to one-fourth of land, and also by higher photosynthetic rates per unit surface area of ocean as compared with land. How this can be true is explained by the considerable depth (100 meters) in which the phytoplankton (free floating plant life) exists. This fact permits extensive photosynthetic activity by these numerous but minute plants. The occurrence of phytoplankton is not limited to salt water but exists in fresh water as well. Here, also photosynthesis with its attendant capture of light energy is active. It has been estimated (10) that in a typical lake—Lake Mendota in Wisconsin, for example—the annual yield of photosynthate by the phytoplankton is well over a ton per acre.

Let us now consider briefly how green plants are believed to use the energy of sunlight. Some of the quanta of the visible light which strikes the green cell are absorbed by the chlorophylls of the cell. Additional light quanta are absorbed by the yellow carotenoid pigments and may, particularly in algal cells, be transferred to chlorophyll. The absorbed energy is then utilized as photochemical energy in the promotion of reactions which result in the splitting of the photosynthetic raw material, water, with the release of gaseous oxygen. The hydrogen from the water is not released as a gas but reacts indirectly with the other photosynthetic raw material, carbon dioxide, to form simple carbohydrate compounds. High energy phosphate compounds are believed to be formed and to function in energy transfer in the complex process of photosynthesis (11). Needless to say, a great many individual steps are involved in the overall photosynthetic process. These include, basically, the steps of the light phase in which the initial absorption and transfer of light energy occurs. Following this is the so-called dark phase (the "Blackman reaction") which also consists of numerous steps —chemical reactions—which gradually advance the initial carbon compounds to carbohydrates and/or other photosynthetic products (fig. 5).

The efficiency of photosynthesis in the capture of light energy can be expressed in terms of quanta, or in terms of percent. Theoretically, three or four quanta of (red) light are required for each molecule of carbon dioxide reduced (12). This would represent 100% efficiency within the photosynthetic system. Actually, eight, nine, ten, or even more quanta of light are required for continued photosynthesis in carefully controlled experiments with actively photosynthesizing algae or

Fig. 5

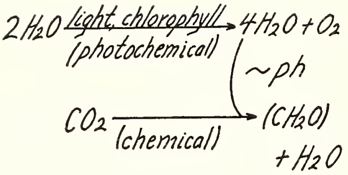


Fig. 6

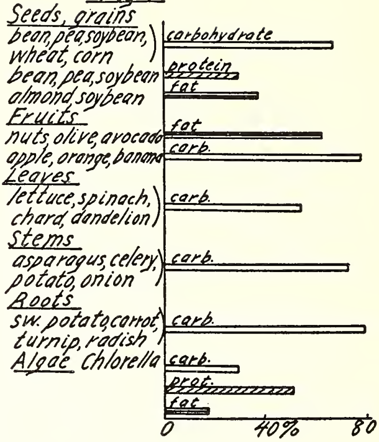


Fig. 8

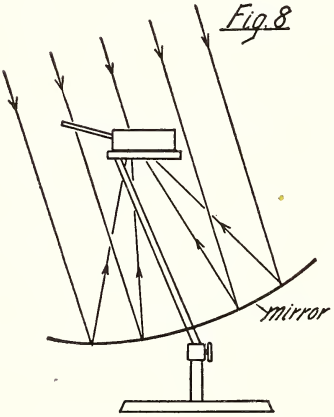


Fig. 7

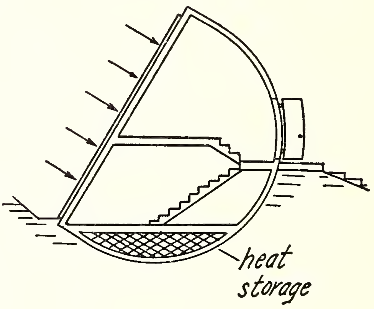


Fig. 5. Simplified schema of photosynthesis ~ph represents high-energy. phosphate; (CH_2O) represents carbohydrate.

Fig. 6. Food contents of some plant parts. Data from Albritton (13).

Fig. 7. Solar heated "house of tomorrow." After Anderson, Hottel, and Austin—in Daniels' and Duffie's "Solar Energy Research" (16).

Fig. 8. Paraboloid mirror solar cooker. After Ghai (16).

green leaves. Ten quanta would therefore represent an efficiency of 30 percent in the use of light energy under the most favorable conditions. For land plants growing in the field, much light energy is lost by reflection from leaf surfaces, transmission through leaves, or absorption by non green leaf and cell structures. As the result, the overall photosynthetic efficiency is reduced to values on the order of 1 to 2 percent.

Man's Use of the Products of Photosynthesis

Man uses the products of photosynthesis for sources of energy as stored in food and fuel, and for protection against discomfort and disease. Foods derived directly or indirectly from photosynthesis consist chiefly of the familiar carbohydrates, proteins, and fats. Varying with the species, one or more of these foods are stored in most parts of higher plants (13). Abundant storage of foods occurs in seeds and grains such as those of beans, peas, soybeans, almonds, wheat, and corn. All of these contain a good deal of carbohydrate (fig. 6), some (beans, peas, soybeans) are rich in protein, and still others rich in fats (soybeans, almonds). Fruits also have served man as important sources of food compounds. Nuts, avocados, and olives are especially rich in fats; apples, oranges, and bananas in carbohydrates to name a few. Leaves, stems, and roots are more apt to be sources of carbohydrates rather than of fats and proteins. Edible leaves include those of lettuce, spinach, and chard; not forgetting dandelions! Edible stems are represented by asparagus, celery, potato tubers, onion bulbs, and bamboo stems—the latter edible only when very young! Edible garden roots are commonly those of sweet potato, carrot, turnip, and radish.

To these well known food sources should be added the algae. Chlorella, for example, has been found to possess a protein content of 50 per cent of its dry weight as compared to 44 per cent for soybean meal, and 12 per cent for wheat grains!

In foods, both energy and tissue-building substances are desirable. With fuels, however, stored energy which can be converted readily into heat and power is of utmost importance. The recently photosynthetically stored energy of sunlight is released as useful heat in the burning of wood in grates and stoves. In the burning of coal, oil, and gas for heat and power, man releases the energy of sunlight captured and stored millions of years ago. Under the then existing conditions of the mild temperatures, moist climate, strong sunlight, and abundant CO_2 supply prevalent in the carboniferous era, vegetation including giant tree ferns flourished, particularly in swampy places. Death of such plants was followed by preservation in the acid swamp waters. Thus layers of plant remains were deposited, preserved, and later covered by sediments. As a result of this deposition, pressure, and warmth, cellulose and lignified cell-wall materials slowly lost their hydrogen and oxygen to become coal, rich in carbon and energy. It has been calculated (14) that one pound of coal contains sufficient energy when harnessed in a modern engine to accomplish as much work as a laborer can do by hand in an entire day. Undoubtedly similar statements could be made for the closely related transformed products, oil and natural gas.

Products of photosynthesis have long been employed by man for his protection. Clothing to protect man's body from the elements has been fashioned from the fibers of plants (cotton, linen) or from the hair of plant-eating animals (wool), or from the hides of plant-eating-animals-eating-animals (leopard skins). Even many of our vaunted modern synthetic fibers go back in their origin via the carboniferous-petroleum route to photosynthetizing plants.

Now that we have man fed, heated, and clothed by products arising out of photosynthesis and solar energy, what about shelter—in other words, housing? When man came out of the caves, or down from the trees, he needed some form of shelter of his own devising. What would be more natural, depending upon the materials at hand, than the construction of grass huts, palm or straw-thatched houses, and finally wooden houses? All of these and more, including tents, are products of photosynthesis made possible by the capture of sunlight. And when we come to live in plastic houses (there are even now plastic greenhouses) we shall still be beholden to sunlight and photosynthesis via the petroleum route.

Finally, sunlight functions as an aid to health and the pursuit of happiness. In addition to the direct effect of sunlight on vitamin D, sunburn, and the cut of bathing suits, the indirect effect on health through herbal medicines has long been exploited. Aside from the various concoctions, mostly of questionable value associated with witches, herb doctors, and tribal medicine men, we still have and use such green-plant drugs as digitalis from the fox glove, quinine from cinchona bark, opium and morphine from the poppy, and atrophine from the nightshade to name but a few.

Man's Machines for Capturing Solar Energy

The problem of capturing solar energy for space heating, cookery, solar furnaces, engines, electric power, etc., is one of collecting and concentrating the diffuse energy of sunlight. Much less energy concentration is required, obviously, for the heating of houses than for the operation of a solar furnace. Both have been effectively accomplished.

Let us consider first of all domestic solar heating of water and of houses. The operation of solar water heaters through the absorption of heat by blackened coils of water pipe has been in use in California and elsewhere for many years. More recently insulated storage tanks have been included to insure hot water on occasional cloudy days as well as on sunny ones.

Space heating in homes by sunlight makes use of various light-capturing and storage devices. Direct illumination through large "picture windows" is one method. Excessive summer heating through southern exposure windows can be avoided by the use of overhanging eaves. On the other hand, windows tilted from the vertical may be used to capture winter sunlight more effectively (fig. 7).

Less direct solar heating has been effected by means of the circulation of air through chambers which are sun heated. Here it may be possible to store solar heat for limited periods by the use of heat-retentive substances such as gravel, water, or solutions present in the system. One unique example (15) is the use of sodium-sulfate solution in tanks in the walls of a house built in New England by a woman architect. At temperatures above 91° F, Na_2SO_4 in solution loses its water of crystallization with the absorption of heat. At temperatures below 91° F water of crystallization is added and heat is evolved. Thus the solar energy absorbed during sunny days is stored and released during cool nights and cloudy periods. It is reported that this system has been effective in keeping both the house and owner warm and comfortable over a period of several years without benefit of coal, oil, or gas for space heating.

In certain areas of the world where sunlight is abundant, but wood, coal, oil and/or other fuels are not, solar cookery may prove to be a boon to man. This condition exists in India and the Indian National Institute of Physics has developed a solar cooker (fig. 8) with a heat equivalent of 350 watts (16). In such cookers solar radiation is focussed on the cooking vessel by means of a 3-foot paraboloid mirror, or by many flat mirrors arranged in a paraboloid pattern. Such cookers are effective but their cost ($15) is prohibitive for the class of people likely to use them. Mirrorized plastics are visualized as a means of cutting the cost of these cookers.

House cooling and refrigeration for the home and industry powered by solar engines have been developed. It is reported that Russia has developed such an installation capable of producing 250 kilograms (550 lbs.) of ice per day (17).

In contrast to solar refrigeration but similar to solar cookery, is the solar production of high temperatures. Furnaces operated by sunlight have been constructed which, as the result of great concentration of solar energy, produce very high temperatures—up to 3500° C. This temperature is higher than the melting point of tungsten.

Solar engines have been constructed as solar-energized steam engines. By means of large parabolic mirrors focussed on water boilers, steam has been generated at pressures up to 7 atmospheres (100 lbs. per square inch) and produced at rates of 100 lbs. per hour. Other engines use flat mirrors and steam, and still others are driven by expanding and contracting gases resulting from intermittent exposure to sunlight.

Solar water pumps and solar water distillation apparatus have been built to meet man's need for fresh water. An Italian pump has been constructed in which sulfur dioxide is vaporized by a "flat-plate" collector and the vapor used to operate a one-cylinder engine. Cooling is effected by the pumped water. Operative solar stills have been built for the purpose of converting brackish water or sea water to fresh water. Present developments suggest the feasibility of such stills to produce drinking water for man and his livestock. The large-scale production by solar distillation of the quantities of fresh water required for irrigation does not yet appear feasible.

Still other methods and systems for capturing the energy of sunlight have been studied. These include photoelectric cells and thermocouples for the generation of electricity, and photochemical methods for the decomposition of water to release energy-rich hydrogen gas. Thus far, these latter methods appear to be still in the theoretical and/or early experimental stages.

Conclusion

In the foregoing discussion we have surveyed some of the interesting features involved in the capture and utilization of the energy of sunlight. Emphasis has been placed upon the nature and source of sunlight and its probable importance as an energy source in the synthesis of the earliest organic compounds and the origin of the simplest forms of life. Photosynthesis in green plants is a process of stupendous magnitude and of great antiquity. By it sunlight is trapped and transformed into the energy of foods and fuels. Modern man is now attempting to supplement the energy of former photosynthetic activity stored in fuels by direct capture and transfer of the sun's energy by the use of ingenious machines. Considerable promise is indicated in this direction but we are probably still a long way from solar-machine manufactured high-energy foods.

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ANTHROPOLOGY

Chairman: Georg K. Neumann, Indiana University
William R. Adams, Bloomingon, Indiana, was elected chairman for 1957

ABSTRACTS

Population Statistics Bearing on a Fort Ancient-Shawnee Linkage. Georg K. Neumann, Indiana University.—As early as 1920, E. A. Hooton and C. C. Willoughby identified the Fort Ancient culture as Algonquian. Later, in 1943, James B. Griffin reaffirmed an Algonquian identification, but expressed his doubts that any specific historic tribe or tribes could be associated with the Fort Ancient manifestation as an Aspect.

A careful comparison of (1) Griffin's historic reconstruction of outside influences on his various archaeological foci within this aspect with (2) the evidence from skeletal material, and (3) with historical data on the movements of the Shawnee bands, lends strong support to the assumption that the Fort Ancient Aspect can be linked with the Shawnee as a tribal entity with a reasonable degree of certainty. This is strengthened by relating the Clover Focus sites in the Monongahela area to Fort Ancient and possibly Shawnee. In each of the three areas—southwestern Ohio, northern Kentucky, and southwestern Pennsylvania—which Shawnees are known to have occupied, historic trade goods have been found in association with artifacts of this culture.

Finally, a population estimate from the number of sites, the number of individuals found in associated cemeteries, and an estimate of the span of time these particular sites were occupied, come very close to the population figures given for the historic Shawnee tribe.

The Racial Significance of an Anomaly Occurring on the Atlas. Louanna Pettay, Indiana University.—A fairly common, non-pathological anomaly occurring on the first cervical vertebrae is the formation of a bar of bone on the posterior arch of the vertebrae. This bony bar bridges the groove for the vertebral artery converting the groove into a foramen. An examination of American Indian skeletal material revealed that in a sample of 111 individuals partial bridging occurred in 18 cases and complete bridging in 20 cases. A comparison of these findings with the results of similar studies conducted on Caucasoid and Negroid material showed no statistically significant differences in the frequency of occurrence of this trait. Consequently, it is assumed that the frequency with which this variation occurs is not influenced by racial affiliation.

Notes on Ceramic Material from Turpin Site, Hamilton Co., Ohio. Edward V. McMichael, Indiana University.—From 1946 through 1949, the Cincinnati Museum of Natural History excavated Turpin Site, located on the Little Miami River near its mouth, just east of Cincinnati. The present study is based on an examination of 15,000 potsherds now stored at Angel Mounds State Memorial.

Two discrete components are represented at the site. The earlier one is late Middle Woodland and the more recent is Fort Ancient. The former is the type site of the Newtown Focus, while the latter is included in the Madisonville Focus.

Ceramically, two major wares, Newtown and Madisonville, are present, representing each component. The Newtown ware is distinguished by crushed rock (including limestone) aplastic, angular shoulders, lack of decoration, and unmodified flat lips. The great majority of sherds have cord-marked surfaces, and the remainder are smoothed over cord-marked. The Fort Ancient, Madisonville ware is crushed shell-tempered, dominantly of smooth surface, though cord-marking occurs in considerable quantities, and often decorated on the smooth neck area of vessels. Decoration, which is restricted to the neck and rim area, consists of trailing and punctation, with the dominant motif being the curvilinear guilloche. The lips of vessels are usually rounded and have folded over rim strips.

Ceramic seriation of the two wares tends to indicate a development from Newtown to Fort Ancient, but other evidence points to a discontinuity between them. Probably the Newtown people left Turpin Site, and modified by Mississipian influence, later returned to the site to contribute the Fort Ancient component.

Music and Values in Some North American Indian Cultures. GEORGE HERZOG, Indiana University.—A connection between the music and the values of a society cannot be traced too easily. In a cultivated, art-music tradition like that of the Western world, very much music is instrumental; it has not text connected with it. It is "abstract" as a rule and does not communicate simply and directly, as does language. In so-called preliterate groups, also in folk societies, the bulk of music is usually vocal; there is text, but its relation to the music and also to cultural background is subtle and intricate—often submerged below an ostensibly simple set of references to cultural factors. Moreover, a preliterate society is rarely articulate in terms of music theory, including esthetic matters; it rarely separates consciously esthetic and "functional" features in music or art; and it does not tend to have an articulated or well-systematized theory of society and its values either.

Nevertheless it is possible to sketch some interesting phenomena in this area; examples are chosen from some North American Indian cultures, with demonstration of music recordings.

The "New England Indians" in the Western Great Lakes Region

EMILY J. BLASINGHAM, Indiana University

There are scattered references in late 17th and early 18th century French documents to the presence of various eastern Algonquian groups in the western Great Lakes region. These Indians, usually referred to as "New England Indians" or "Loups" by the French, were Abnaki, Sokoki, Mahican, and Minisink, as well as other Algonquian-speaking groups which cannot now be identified from the names given in the French sources. During the late 17th century, all of these groups inhabited a territory near the eastern seaboard which extended from Maine in the north to the headwaters of the Delaware River in the south (5).

By mid 16th century the Indian groups of the New England coast were carrying on an extensive fur trade with Europeans and the heavy demand for beaver was causing the rapid extinction of this animal along the eastern seaboard. As early as 1616 Indians from New England had penetrated westward as far as the Great Lakes to obtain furs (9), and the Abnaki had encountered the Miami Indians (probably then located in Indiana and southern Michigan) sometime prior to 1680. Robert Cavelier, Sieur de La Salle, states in 1681 that the Miami called all Indians from New England, regardless of their tribal affiliation, Abnaki. According to the Miami, the Abnaki were the first Indian group from the eastern seaboard to contact them when they came west to trade for furs. Also acording to the Miami, all the Indians from New England spoke closely related dialects. The trade excursion of the Abnaki to the Miami evidently occurred some time prior to 1681, but La Salle gives no precise date for it. It is probably due to such early trade expeditions by eastern Indians that European trade articles are found on protohistoric sites such as Madisonville in southwestern Ohio.

During the winter of 1680-1681 La Salle found at the mouth of St. Joseph River, Michigan, 20 or 30 Indians accompanied by their wives and children. La Salle notes that these Indians were from "various tribes among those who are at war with the English." (It should be noted that King Philip's War between the English and the Indians of New England had ended three years before.) According to La Salle, some of these Indians were from "Boston, some were Moraiganés [Mahican], Anhanaganes [identification unknown], Mahiganés [Mahican], and Minissens [Minisink]." They had been wandering for some years with no fixed dwelling place. Not wishing to settle near any French settlement because of the scarcity of beavers and also because of the difficulty of making clearings in the northern forests, they intended to hunt beaver in present-day Indiana or Ohio. Then they were either going to amalgamate with the Iroquois or to find some good land elsewhere to settle on. La Salle was able to convince this group to settle at a Miami village located near the St. Joseph-Kankakee portage (near present-day South Bend, Indiana), pointing out to them the fertility of the soil, the abundance of beavers and buffalo in the region, and also the probability in the near future of cheap trade goods and a supply of horses and other draft animals as soon as he (La Salle) opened up a trade route to the Gulf of Mexico *via* the Mississippi River. The Loups, as La Salle called these Indians, were happy to stay since the Kankakee-St. Joseph drainage area was rich in game, and the Miami were glad to adopt the New England Indians since they would replace two cabins of Miami who had been killed by the Iroquois during the winter of 1680-1681. After the completion of the adoption ceremony at the Miami village near the portage, the Loups returned with La Salle down the St. Joseph to his fort at the mouth of the river, where they planted their crops. Exactly what crops were planted we do not know; it is possible that some European vegetables as well as corn, squash or pumpkin and beans were planted.

In order to increase his settlement, La Salle proposed to the New England Indians that they send a present of 50 beaver skins to each of the tribes they had originated from, and invite these tribes to come west to join them at their location near present-day Benton Harbor, Michigan. The New England Indians agreed to do this and sent two of their number, Ouabach and Amabanso, east to issue the invitation (7). Evidently this mission was accomplished during the summer of 1681 for we find that Amabanso returned to the St. Joseph River region in time to accompany La Salle in his exploratory trip to the mouth of the Mississippi River in 1681-1682. Thirteen other New England Indians were also hired by La Salle as hunters for his exploring party. Some of these Indians were accompanied by their wives (10 in all) and by three children. The tribal affiliations of some of these women suggests where this group of Indians may have been wandering before going west; there were three Nipissing (an Algonquian group then living at Lake Nipissing in Canada), one Ojibwa (Chippewa), one Huron, and five Abnaki, Sokoki or Mahigans. Besides hunting for the French, the New England Indians also constructed elm bark canoes for use by the party on the Illinois and Mississippi rivers (8, 10).

After the return of La Salle's party from the Mississippi venture in the summer of 1682, the New England Indians evidently remained associated with the Miami. In 1687, after the Miami had moved from the St. Joseph River to the vicinity of the Illinois Indian village of Kaskaskia and the French post of Ft. St. Louis on the Illinois River near the present Utica, Illinois, Henri Tonty, La Salle's lieutenant, was able to gather a few "Loup" warriors to accompany a large group of Illinois and Miami for the mass French-led Indian attack on the Iroquois (6).

However, two years before this (in 1685) Nicolas Perrot, French official and trader then stationed on the Mississippi River near present-day Trempeleau, Wisconsin, encountered near Green Bay "fifty Sokokis and Loups, from those who had been with Monsieur de La Salle in his voyage of discovery [of 1681-1682] . . . who had retired to the bay

[Green Bay] in order to hunt beavers there" (1). It should be pointed out that La Salle took 18 Indians in all with him down the Mississippi and only 14 of them were "New England" or "Loup" Indians. It is possible that some of La Salle's group were included in the party encountered by Perrot. However, from statements made by Perrot and Tonty in 1687, it is evident that there were at least two groups of New England Indians in the western Great Lakes region. One group was associated with the Miami and Illinois as mentioned above and the other, residing in a Mascouten village in Wisconsin, was distinctly anti-French and pro-Iroquois. This group shortly thereafter returned east (2).

Thirteen years later, in 1700, both Mohegan and Sokokis wintered in the vicinity of St. Joseph River in association with the same Miami group that had adopted them in 1681. Shortly thereafter the Miami moved to Detroit and the New England Indians evidently moved with them, for in 1706 we find that many of the Miami as well as the "Loups" left Detroit (3, 4).

This is the last reference found in the literature which associates any of the New England Indians with the Miami. It is entirely possible that after this date the New England Indians were completely assimilated by the Miami and lost their identity as a separate group. It is also possible that after this date the New England Indians lost their function as middlemen fur traders. In 1680, the date of first recorded extensive White penetration into the region, trade was carried on largely by various Indians bringing trade goods into the area from European posts to the east and north. However, after the establishment of near-by French trading posts, the Indians of Indiana, Michigan, and Illinois became aware that they too could carry on direct trade with the Europeans and no longer needed to rely on Indian middlemen such as the New England Indians earlier had been.

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Remarks on the Physical Type of Certain Middle Mississippi and Southeastern Groups

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It has been generally concluded for some time that archaeological Middle Mississippi is ancestral to the historic Southeastern Indians. Archaeological remains have been correlated with historical Southeast groups on the basis of cultural inventories, especially ceramic traditions, while ethnologists have had the unique opportunity of reference to early and unusually detailed accounts of native life as recorded by Spanish and French explorers, notably DeSoto, in the Southeast in early post contact times. It seems clear from the historical record that DeSoto encountered numerous groups that were practicing what is generally recognized as a Middle Mississippi culture. Archaeological evidence seems also to bear out this relationship. The affiliation then has been made on the basis of alleged demonstrable cultural continuity without the benefit of active or formalized support of physical anthropology. It is somewhat surprising that the physical approach to the problem has not been attempted in that population relationships, and therefore movements, migrations and likely cultural contacts, may be reconstructed on physical evidence with a degree of certainty not attainable by other anthropological means. This paper is a report on a project designed to establish more firmly, on the basis of physical anthropological evidence, the association of archaeological Middle Mississippi and historical Muskhogean.

The problem is of two parts:

1. Establishment of the subject Southeastern groups as valid members of a specific variety of Amerind and,
2. Association of the varietal type with a population of the Middle Mississippi Phase.

In order to achieve these objectives a series of crania from five Middle Mississippi components and from four Southeastern tribal groups (Creek, Choctaw, Chickasaw, and Yuchi) have been analyzed anthropometrically. Neumann (2) has fully described a Middle Mississippi series of forty-five undeformed adult male crania from the Spoon River Focus of central Illinois. These crania served as the type series for the Walcolid variety of the North American Indian. The archaeological material associated with the skeletons has been reported by Cole and Deuel (1).

A group of eight skulls of known tribal affiliation, including three male Choctaw, one male and one female Yuchi, one female Creek and two female Chickasaw were available in the Indiana University collection and will represent the Southeastern Muskhogeans in this paper. While the Spoon River series is adequate and suitable for statistical treatment, the crania of known tribal affiliation do not constitute a valid statistical sample, but furnish important evidence because they are a homogeneous group. Although all are adult and none deformed, four (or one-half) of the crania are female and therefore second best as indicators of racial characteristics. It must be emphasized then that the series of Southeast crania presented here are to be regarded with reservation. Additional skulls will strengthen the series in every respect.

Description of the various series under consideration is not possible here but in summary comparison the historic crania taken collectively appear to be significantly close to the Walcolid type in observational morphology. The historic male skulls (Choctaw and Yuchi), like the Spoon River Focus Walcolids, are medium to large in size and muscularity. The Walcolids and historic males are ovoid or ellipsoid in shape and within a range of three index points of one another in length-breadth proportions. Brow ridge size and frontal height center around medium, frontal breadth is moderate while slope is generally medium but sometimes slight. Sagittal elevation is generally absent or small, parietal eminences medium, lambdoid flattening absent to small, the occipital most often medium in position and infrequently low, while breadth is moderate. Mastoids are either medium or large; platybasia is absent. Face size tends to large with rhomboid or square orbits of medium or less inclination. The nasals are medium in size and exhibit a slightly concavo-convex profile. The nasal root height is moderate while nasal root breadth and nasal bridge height and breadth tend around medium. The malars are medium to large in size and height and show pronounced lateral projection and sometimes medium but most often a large degree of projection to the front. Prognathism is generally medium but can be less.

The historic males were found to be closer to the Walcolid type (a male series) than any of the females. The Choctaw males, as compared to the Walcolid series, have slightly smaller and rounder but essentially identical vault configuration. The length-height proportions are likewise similar—both high. The Choctaw are slightly smaller in facial dimensions but are the same indically. The Choctaw and Walcolid nasal and orbital structures are identical.

The Yuchi male is close to the Walcolid except that the vault is somewhat round, a condition due to the appreciable shorter glabello-occipital length. The latter, however, falls within two standard deviations of the Walcolid. The length-height ratio is the same for both groups. The facial characteristics are identical in both size and proportion, the Yuchi being closer to the Walcolid than are the Choctaw in this respect. The Yuchi nasal structure is very nearly identical but somewhat more narrow in relation to length. The male Yuchi orbital dimensions and proportions are identical to the Walcolid.

In a word, the Walcolid, Choctaw and Yuchi males have been found to be highly similar morphologically and anthropometrically. Metrically and indically the skulls are essentially identical except that the Yuchi is somewhat more round-headed than the Walcolid or, to a lesser extent, the Choctaw.

The comparison then of forty-five male Middle Mississippi skulls, from the Spoon River Focus, Illinois, with eight crania of known Southeastern affiliation, has shown them to be closely related physically and both valid members of the Walcolid variety of Amerind. A continuity of physical type is therefore demonstrated, corroborating the archaeological-historical correlation heretofore made with cultural data.

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Pottery Figurine Heads from the Valley of Mexico

Francis X. Grollig, Indiana University

Archeologists have always been intrigued by the little figurine heads that were produced in such a copious abundance in the Valley of Mexico. While visiting more than a dozen archeological zones in the summer of 1956, the author acquired those shown in plate 1.

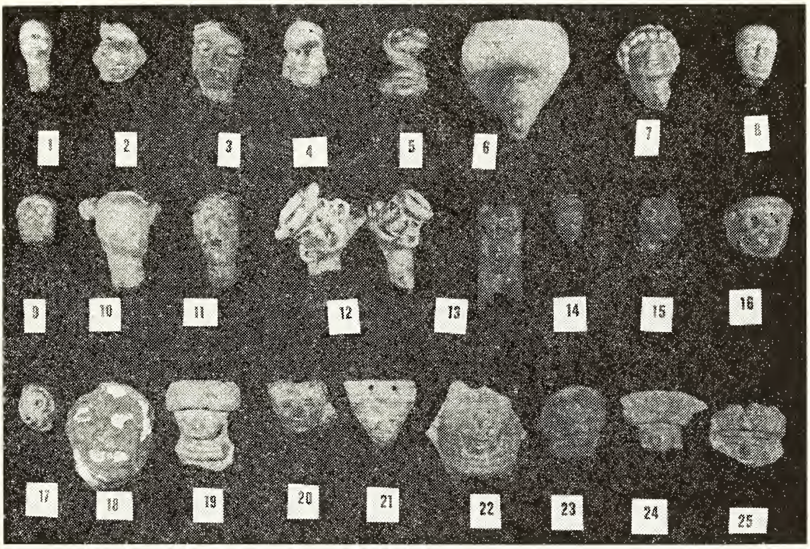

Plate 1
Pottery Figurine Heads from Central Mexico

Competent authorities have come to realize the importance of figurines as a reliable index to the culture and chronology of the manufacturers of these tiny heads—they average less than 3 cm. each. Some of their conclusions are verified here. The numbers refer, of course, to the figurine numbers in the plate.

There are four techniques for making these clay heads. They are hand fashioned, with features: a) cut into the clay, No. 1; or b) cut out of the clay, No. 16; or c) added to the basic form, No. 4; or, they are fashioned entirely in a mold, No. 23. This last class is usually easily distinguished from the others by the mold line visible at the back of the figurine.

With reference to the formation of the anatomical parts, especially the eyes, Herbert J. Spinden (3) devised the following classification: "First there is the simple groove; second, a groove across an applied ball of clay; third, a round gouge made by the end of a blunt instrument held vertically; fourth, a round gouging in an applied ball or button of clay; fifth, two gougings made with a round chisel-edged implement held at an angle." To these he adds two more classes, those with carefully modeled eye-lids, and those with eye-balls added between the lids. Examples of the last of these six classes are given in the plate, Nos. 3, 4, 7, 8, 17 and 19. No. 18 is a typical example of the painted type of face on Cholula figurines; No. 2 lost one of his button-like eyes; and No. 15 seems to elude this classification entirely.

Relative chronologies of figurine types have been worked out and these have relied heavily upon these anatomical variations. George C. Vaillant (4), for example, discusses five types of Teotihuacan figurines, and Eduardo Noguera (2) classifies ten types of heads from Cholula. In each of these series a self-contained chronology is established.

The cultural index-value of the figurines can be realized when one examines some aspects of the accompanying small group. There are represented a variety of hats and hair styles, Nos. 12, 19 and 5, 7; ear-rings, Nos. 5, 20; and a nose-plug, No. 4. Physical Anthropologists immediately notice the relatively thick lips in both archaic No. 2, and classical Teotihuacan types, No. 8.

Of equal interest are the uses to which these figurines were put. Both human and zoomorphic forms were made for handles for vessels, Nos. 6, 12; for whistles, Nos. 10, 11; and for pendants, Nos. 13, 14, 21. Some were used for votive offerings; maybe this accounts for the metallic (gold?) particles adhering to No. 1. Spinden (3) speculates that the female and male figurines may have been used, respectively, as fertility amulets to secure good crops and offerings for success at arms.

Thomas Joyce (1) does a masterful job at giving verbal descriptions of the gods and goddesses represented in the medium of figurine heads. Some appearing in the group under discussion are: Tlolac, god of rain, with his rain-drop eyes, No. 22; Xiuhtecutli, deity of fire, with his butterfly head-dress, No. 23; Coatline, deity of death, with her vacant stare, No. 9; Xochiquetzal, goddess of flowers, love and pregnancy, with her coronet of corn and feathers, No. 24.

Obviously, it is no exaggeration to say, with Dr. Eduardo Noguero: "De capital importancia para las investigaciones arqueologicas de Mexico son las figurillas humanas."

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BACTERIOLOGY

Chairman: Eugene Weinberg, Indiana University
Edward W. Shrigley, Indiana University, was elected chairman for 1957

ABSTRACTS

Bacterial Dissimilation of Alpha-conidendrin, a Naturally Occurring Lignan. W. A. Konetzka and Jean Stove, Indiana University.—Although it has been established that in nature certain of the wood-rotting fungi attack lignin, the study of the mechanism of microbial lignin degradation has been hampered by the failure to isolate any products of dissimilation. This investigation of the bacterial dissimilation of alpha-conidendrin was undertaken to determine the manner in which complex lignin-like compounds are attacked by microorganisms.

Simultaneous adaptation studies reveal that alpha-conidendrin-grown cells oxidize conidendric acid, alpha- and beta-conidendrol, vanillic acid, p-hydroxybenzoic acid and protocatechuic acid. Vanillic acid-grown cells oxidize p-hydroxybenzoic and protocatechuic acids, while p-hydroxybenzoic acid-grown cells oxidize protocatechuic acid. This information together with chromatographic and spectrophotometric analyses of the products of dissimilation leads us to propose the following tentative scheme for conidendrin dissimilation: alpha-conidendrin → conidendric acid → ? → vanillic acid → p-hydroxybenzoic acid → protocatechuic acid.

The Effect of Temperature on Survival of Mixtures of *Escherichia coli* Substrains. Harold W. Bretz, Purdue University.—Two colonial mutant substrains designated ground-glass (gg) and flat-irregular (fi) were isolated respectively from each of two stock *Escherichia coli* strains: parent # 61 opaque (op) had a 25 to 27 minute generation time and was streptomycin resistant while parent # 7006 (op) had a 15 to 17 minute generation time and was streptomycin sensitive.

Various 50:50 mixtures of 10^8 cells per ml from washed slant cultures were stored in pH 7.0 Sorensen's M/15 phosphate buffer at 37°, 4°, and minus 9°C for ten weeks. Samples were examined at 0, 3, 6, and 9 weeks for total count and the proportion of substrains. Growth curves on single substrains and on mixtures were determined before and after 10 weeks storage at –9°C only. (The initial interest was in the change in generation time or lag time during –9°C storage.)

Data show that certain mixtures will survive at 37° and –9°C though not at 4°C but that no predictions can be made concerning any correlation between temperature, original parent strain, or colonial substrain. Substrains may not have the same growth curve characteristics as their parent strain, and a given substrain may survive in one mixture but succumb in another. Some mixtures even showed a subsequent increase in numbers during storage. Several speculative interpretations are suggested including autophagy, increased recombination rate, phage infection, or ploidy.

Requirements for Complete Oxidation of Acetate by Azotobacter Extracts. JOHN J. JOSTEN and R. REPASKE, Indiana University.—Crude sonic extracts prepared from ethanol grown *Azotobacter vinelandii O* have been investigated to determine conditions for complete oxidation of acetate. Preliminary studies showed that these extracts completely oxidized acetate to CO_2 and H_2O provided a minimal amount of "sparker" was present. Cofactor requirements were not absolute; however, the rate of oxidation was increased by inorganic phosphate, GSH, DPN, and coenzyme A with tris (hydroxymethyl) aminomethane as buffer. The response to inorganic phosphate was greater than with the other supplements. If the optimum concentration of phosphate ($5 \times 10^{-3}M$) were exceeded, the rate of oxidation decreased, but the maximum rate could be reestablished by increasing Co A. This suggests the presence of phosphotransacetylase.

No evidence was obtained for acetate oxidation occurring other than through the TCA pathway; a "sparker" was required for complete acetate oxidation as was shown by other investigators. Inhibitor studies with malonate and fluoroacetate further supported this hypothesis.

Acetate oxidation via the TCA cycle requires activation of acetate to acetyl-PO_4 or acetyl-Co A presumably by ATP in the extract and that formed during oxidation of substrate. Sufficient adenine nucleotides are present because their addition causes little stimulation. Although P/O ratios with these preparations range only between 0.1 and 0.3 with the hexokinase-glucose system as acceptor, the fact that acetate oxidation occurs at a rapid rate suggests there is rapid and extensive phosphorylation. There may be an ATP system which activates acetate with greater facility than it phosphorylates glucose. This possibility is now being explored.

An Improved Petri Dish Cover

Robert I. Fletcher, DePauw University
Greencastle, Indiana

Julius Petri, a German bacteriologist, in 1887 developed a round, glass dish in two parts in which he was able to grow and observe isolated bacterial cultures. This invention by Petri proved to be a very useful piece of apparatus which has become standard in all bacteriological laboratories.

Advances in technique and in equipment frequently present new problems and the introduction of the petri dish was no exception. Hot media in a closed container, such as the petri dish, causes the condensation of moisture on the cooler glass. The condensate forms into droplets which are suspended from the lower surface of the cover. Consequently, the cover becomes fogged and frequently makes easy observation of the culture growth difficult unless the cover is removed thus rendering the culture vulnerable to contamination. Also, the condensate may drop to the surface of the medium and disturb the growth so that the characteristics are not natural. This condition is often extremely annoying, especially when critical work is being done.

Several different techniques have been suggested to overcome these difficulties. One has been to pour the medium, allow it to harden, and then raise the cover into such a position so that air can circulate through the dish and evaporate the condensate from the cover. Obviously, this method introduces the increased probability of contamination. Another method has been to invert the dishes containing the solidified medium and place them in an incubator to evaporate the condensate from the under surface of the cover. A clay petri dish cover was devised which absorbs the condensate, but this type of cover created two new problems. First, the opaqueness of the cover prevents ready observation of the surface of the medium, and second, the cover, which acts somewhat like a blotter, increases the rate of water loss and, consequently, a more rapid drying of the medium.

Another device employing a metal ring fitted with a paper insert was developed. This cover has the disadvantages of being opaque, of allowing the moisture to evaporate too rapidly as in the case of the clay cover, and of having joints into which contaminants can find their way.

Thus, the problem of condensation in petri dishes has not been solved completely and satisfactorily and the bacteriologist has continued to be handicapped with inadequate methods of eliminating condensate.

A new, improved, transparent petri dish cover which controls the condensate has been devised (Fig. 1a, 1b). This new cover is made of fracture-resistant glass with the lower surface gradually sloping from the margin to the center where a glass stud holds an absorbent disc of specially prepared paper. The paper disc is similar to filter paper in

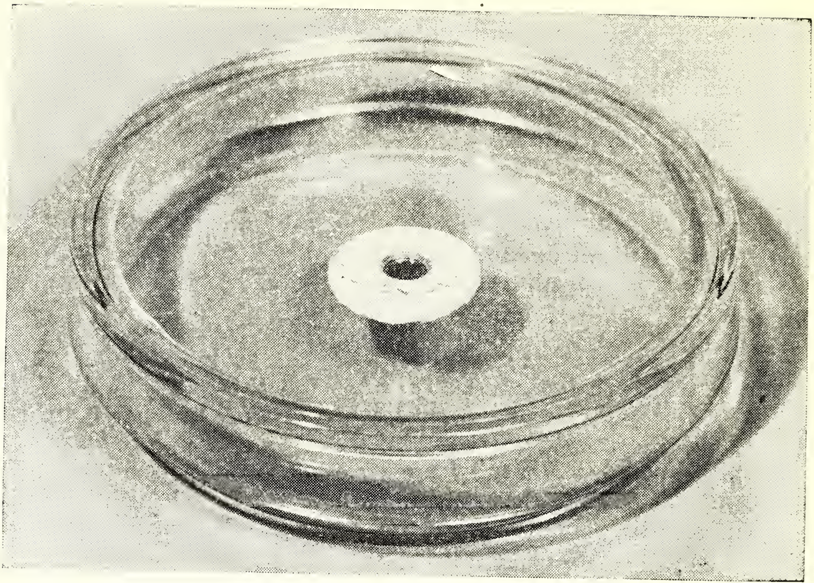


Fig. 1a. Top view of The New Improved Petri dish cover.

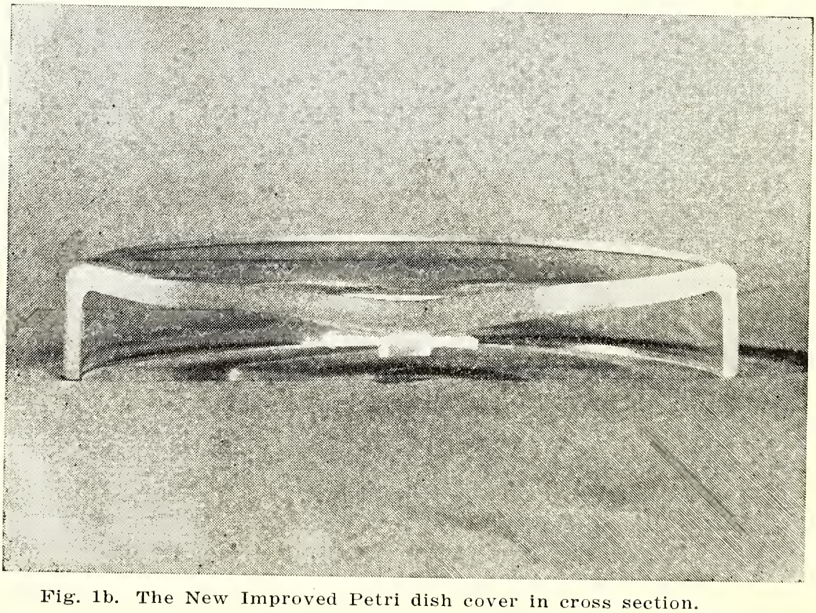


Fig. 1b. The New Improved Petri dish cover in cross section.

composition but will withstand the temperatures of dry heat sterilization. The condensate under the influence of gravity flows toward the disc where it is absorbed. The new cover with the absorbent disc attached is used with the lower half of a standard 100 mm. petri dish. The complete petri dish, including the absorbent disc, is assembled and sterilized in dry heat in the usual manner.

The heated medium is placed in the dish in the customary manner, using sterile technique, and the dish is immediately closed. By the time the medium has solidified, most of the condensate will have been absorbed by the disc, thus leaving the cover clear for observation of the surface of the medium. Condensate, being held in the absorbent disc, cannot drop onto the surface of the medium. The cover, being used in the same manner as an ordinary cover, reduces the possibility of contamination by air currents since it is not necessary to open the dish except for the introduction of the medium and/or for inoculation. In addition, the moisture is contained within the dish and thus tends to prevent the medium from rapidly dehydrating.

It is believed that the improved petri dish cover will be very useful wherever it is necessary to observe cultural growth.

This new, improved petri dish cover is available from the A. S. Aloe Scientific Company, St. Louis, Missouri.

Detailed Procedure for Using The New, Improved Petri Dish Cover

1. The covers should be thoroughly cleansed using a detergent or a cleaning solution to remove any film from the glass.
2. The covers should then be rinsed well in clear water and allowed either to air-dry or be wiped dry with a lintless cloth.
3. The special absorbent disc should then be placed on the glass stud so that the lower surface of the cover is in direct contact with the disc. The opening in the center of the disc is slightly smaller than the diameter of the stud, thus requiring a slight pressure to force the disc into proper position.
4. The cover is now placed over the bottom half of a standard 100 mm. petri dish. Sterilization should take place in dry heat to promote maximum absorption by the disc.
5. After sterilization, the dishes are ready to be used in the usual manner. Up to 20 ml. of medium may be used in a 100 mm. petri dish without causing direct contact between the medium and the glass stud.

Structure of the *Paramecium aurelia* Macronucleus as Revealed by Electron Microscopy

Ruth V. Dippell and T. M. Sonneborn, Indiana University

The structure and organization of the macronucleus of ciliated Protozoa poses one of the most intriguing and as yet largely unsolved problems in cytogenetics. This nucleus, essential for the survival of the organism, divides amitotically, disintegrates during sexual reproduction and is replaced by a new one arising from a micronuclear product. Although the micronucleus possesses chromosomes, as it develops into a macronucleus, the chromosomal entities seem to disappear. What becomes of these chromosomes during macronuclear development and how this chromosomal material is organized in the adult macronucleus is still unknown. In *Paramecium* other investigators have shown this nucleus to contain Feulgen-positive material in the form of a coarsely precipitated network in stained preparations and to manifest two types of structures in living condition under phase contrast: large bodies believed to be nucleoli and a multitude of fine filaments at the limit of visibility of the light microscope (chromosomes?). Electron micrographs taken by other investigators confirm this general picture.

A more extensive and detailed EM analysis of macronuclear structure and organization by the present authors confirm and extend these observations; the largest bodies in the nucleus (0.5-1.0 micron) are certainly nucleoli; they have been observed under bright and phase contrast and can be shown to give typical reactions to nucleolar stains and enzyme preparations. They are largely Feulgen-negative; RNA positive. The other organized structures in the macronucleus consist of small particles or rodlets varying somewhat in size and shape (maximum width approx. 0.1 micron; variable length up to 0.6 microns (rare)). These are scattered randomly throughout the nucleus and are believed to represent randomly oriented cuts through chromosomal material. Ultrastructure has been observed within these granules in the form of alternating light and dark bands or dots, roughly 200A thick, strongly suggesting a microfibrillar chromosomal organization as recently described for higher forms. Further investigation of this ultrastructure is necessary. Comparison of prometaphase meiotic chromosomes of the micronucleus as seen by light microscopy with these presumptive macronuclear chromosomes permits a crude estimate of ploidy level to be established at approximately the 100-ploid level, a result in good agreement with other independent methods of estimation.

BOTANY

Chairman: Charles W. Hagen, Indiana University
Alton A. Lindsey, Purdue University, was elected chairman for 1957

ABSTRACTS

The Production of Pigments in Flowers of *Impatiens balsamina*. Charles W. Hagen, Jr., Indiana University.—In *Impatiens balsamina* the gene H affects in a similar manner the structures of both leucoanthocyanins and anthocyanins, a relationship which indicates a common feature in the synthesis of the two classes of compounds. Three possible relationships are apparent. If leucopelargonidin serves as a direct precursor for pelargonidin then the quantity of leucopigment should decrease as the visible pigments are formed. If the two compounds are formed from a common limited precursor, then the formation of leucopigments should diminish as production of the greater quantity of visible pigment commences. If the common precursor is abundant or if the specific pigment production depends upon modification of the completed structures there should be no interference between the two compounds. Preliminary assays of developing buds of red-flowered plants indicate that leucoanthocyanin synthesis continues until formation of visible pigments begins. Beyond this point the total leucoanthocyanin content remains essentially constant. This would suggest that the second of the three alternatives is correct.

The Use of Tissue Culture for the Study of Anthocyanin Synthesis in the Petals of *Impatiens balsamina*. Attila Klein, Indiana University.—Young petals of *Impatiens balsamina* were cultured in a simplified White's medium. They were found to be capable of producing their normal spectrum of pigments if light, inorganic salts, vitamins and sucrose were supplied. The method may be adapted to test the degree of participation of possible precursors in the biosynthesis of flavonoid pigments. In preliminary experiments caffeic acid, dihyroxyphenylalanine and ascorbic acid, when added to White's medium, increased the pigment yield by 25 to 50%.

The Flavonols of *Impatiens balsamina L.* Sarah Clevenger, Indiana University.—Previous workers have determined the anthocyanidins and leucoanthocyanidins found in the flowers of the various genotypes of *Impatiens balsamina L.* The leucoanthocyanidins present yield pelargonidin, cyanidin, and delphinidin. The flavonols found in the flowers seem to be the analogs of these leucoanthocyanins. Kampherol, which has a hydroxylation pattern like pelargonidin, is found both in the petals and sepals of all genotypes investigated. Quercetin which is analogous to cyanidin is found in the sepals, but is lacking in the petals. A third flavonol, possibly myricetin, is correlated with the presence of a single gene which also affects the anthocyanin structure. These results indicate that the anthocyanins, the leucoanthocyanins, and the flavonols may have similar or related pathways of biosynthesis in the garden balsams.

A Shoot Elongation Assay for Gibberellic Acid. C. E. HIGGENS and J. M. MCGUIRE, The Lilly Research Laboratories.—A procedure employing the shoot elongation response of dwarf peas to gibberellic acid can be used to determine the potencies of fermentation broths and purified preparations. The emerging leaves of Little Marvel pea plants are treated with standard or sample solutions. A dose-response is obtained 6 days after application. Details of the assay method are described.

The Influence of Age and Maturation Temperature of Wheat Grains on Plant Development. J. A. RIDDELL and GEORGE A. GRIES, Purdue University.—Spring wheat plants grown from seed harvested in different years vary in their rate of development with late maturing varieties showing the greatest variability. A vernalizing treatment overcomes most of the variation and hastens the development of the slower plants. Rate of development is not correlated with age of seed. Plants of the winter wheat variety, Knox, grown from seed matured at 60°F require a shorter vernalization time for maximum rate of development than those grown from seed matured at 80°F. It is suggested that the variations in growth rate of spring wheats from seed of different ages is related to the temperature during maturation rather than age or conditions during storage.

The Geographic Distribution of Ceratopteris pteridoides. CHARLES E. DEVOL, Marion College.—*Ceratopteris pteridoides* was described from plants collected in British Guiana. Hooker placed it in a new genus *Parkeria* because of the absence of an annulus. However, Hieronymus recognized it as a species of *Ceratopteris* and it has been considered by most authors as such since then. This fern which usually is a floating fern has been collected in many parts of South America from Colombia to Argentina. It is also found in the West Indies, Central America and Florida. In 1941 I collected it in the reed marshes along the Yangtze River, near Nanking, China. Many plants found in Eastern Asia have been found in Eastern United States and this is another to be added to that list. It was collected by Balansa in 1891 and Mouret in 1906 in Tonkin, and Mme. Tardieu-Blot shows an illustration of it in the Flora Generale de L'Indo-Chine. However in these cases it was called *C. thalictroides* and Mme. Tardieu-Blot does not distinguish between the two species, although they differ widely in many respects.

Sidney collected it in Bengal, India, in 1944 (in the part of India now known as Eastern Pakistan). In the Herbarium of the Chicago Natural History Museum is a specimen from Madagascar, which bears no data except the word "Madagascar," which came from Herbier Jeanpert.

Thus this fern which has been considered an American fern is found from Eastern China to Eastern India and in Madagascar. Most collectors report it as *C. thalictroides* and since both species are found in the same area it is likely that it is much more widely distributed than the present records show.

A Unique Color Reaction of a *Penicillium* Sector. JOSEPH M. RIEDHART and C. L. PORTER, Purdue University.—Preliminary investigations were carried out to characterize a color change induced by the action of light on a *Penicillium* sector. The sector, isolated from a *Penicillium* species tentatively identified as *Penicillium herquei*, changes from a yellow to a green color upon exposure to light. A similar change occurs when the organism is exposed to the vapor of ammonium hydroxide.

Oak Wilt in Southern Indiana. FOREST STEARNS and HAROLD CROWDER, Purdue University and Indiana Department of Conservation.—Investigation of the distribution and rate of spread of oak wilt, was carried out in 1956 under a cooperative arrangement between Purdue University and the Indiana Department of Conservation. Distribution of the disease in northern Indiana has been studied in detail in past years and field work during 1956 was concentrated in southern Indiana.

Cultures of the causal fungus, *Endoconidiophora fagacearum* Bretz, were obtained from dying oaks in Crawford, Jefferson, Spencer, and Washington counties. Positive identification had previously been obtained from other locations in Brown, Crawford, Dubois, Greene, Marion, and Washington counties in the years 1951 through 1954. Suspected areas from which cultures of the organism could not be secured exist in Clark, Dearborn, Dubois, Franklin, Jackson, Jennings, Martin, Monroe, Owen, Ripley, Scott, Switzerland, and Vigo counties. Surveillance of these areas will continue.

On the basis of the current limited field work, oak wilt does not yet appear to be a common disease in southern Indiana. However, pockets of infection are scattered throughout the entire oak area.

A Film Impression Method for the Observation of Minute Features of Wood Anatomy. H. O. BEALS, Purdue University.—Cellulose acetate ribbon in combination with a solvent of cellulose acetate in acetone can be used to obtain accurate surface impressions of wood specimens for microscopic study. Impressions may be made of many woods without surface treatment with some loss of detail, however, a simple pretreatment will improve the replica. Such features as simple and bordered pits, perforation plates, and ray crossings can be observed at magnifications of 400x.

The time required to make such an impression on untreated wood specimens is approximately 90 seconds. This method can be used to verify identification of wood specimens without the preparation of freehand sections.

Wood Anatomy of the *Canellaceae*. THOMAS K. WILSON, Indiana University.—The *Canellaceae* consists of five arborescent genera which are distributed throughout the subtropical and tropical regions of the Western Hemisphere, Africa, and Madagascar. The natural affinities of this family are much in doubt, having been placed at one time or another by various authors in different orders. Quite recently the

Canellaceae has been made the sole family of a new order, the *Canellales*. In view of the conflicting opinions concerning the phylogeny of this family, a comprehensive investigation of its vegetative and floral morphology has been initiated.

Preliminary investigations of the wood anatomy in nine species reveal that the *Canellaceae* appears to be a natural grouping. The wood shows a fairly low level of specialization, a condition which is not in accord with the high rank given this family in most systems of classification. After comparing the wood anatomy of the *Canellaceae* with that of various putatively related families, it became apparent that the greatest number of similar anatomical characters exists between the *Canellaceae* and certain families in the woody *Ranales*.

Failure of Metaxylem Development as a Cause of Wilting in a Corn Plant. S. N. POSTLETHWAIT and O. E. NELSON, Purdue University.—Maize plants which are homozygous for a single recessive factor, wilted, are chronically wilted from shortly after the seedling stage through to maturity regardless of the water supply available. This chronic wilting, which is most marked in the younger leaves, results in pronounced dwarfing of the plants. Wilted plants are able to shed pollen but set ears only under exceptionally favorable conditions. As growth progresses, the older leaves regain turgidity and are apparently receiving a normal supply of water. Examination of sections of stem from normal and wilted plants have shown that the basis for the wilted phenotype is a significant delay in the formation of metaxylem vessels in the vascular bundles. Vascular bundles in the younger sections of the stem are poorly supplied with metaxylem vessels although protoxylem vessels are present as in normal plants. Vascular bundles in the older sections of the stem are nearly, if not entirely, normal, accounting for the normal appearance of the lower leaves as the plant matures.

Raindrops as Plant Dispersal Agents

HAROLD J. BRODIE, Indiana University

Introduction

Among the characteristics of a plant likely to increase its capacity to survive, none is more important than an efficient means of dispersing its spores or its seeds. Dispersal is accomplished by plants through a variety of adaptations involving practically every natural force and agency. Although the facts about dispersal are generally well known, and have been for a long time, the importance of rain in this connection has been neglected or minimized. Yet, even where rainfall is sporadic, it represents a powerful natural force which many kinds of plants have "utilized" as one capable of bringing about the dispersal of their spores, seeds, pollen, and other propagative units.

The recognition of numerous small cup-shaped plant structures as specialized organs from which raindrops splash spores and seeds is a simple matter. Its very simplicity and obviousness may be the reason for the neglect of this concept by a considerable proportion of the modern textbooks of botany and of general biology. Since the first clear and complete account of the "splash-cups" of the fungi belonging to the family Nidulariaceae given by Buller (7) in 1942, the researches and observations of Brodie (1, 4) and others (7, 8, 9, 14, 15, 16) have revealed the existence of rain-operated dispersal mechanisms in thirty species representing almost all groups of land plants.

One of the most impressive features of the splash-cups of plants is their uniformity of size and structure. The fruit body of the fungus *Cyathus*, the rosette of the male plant of the moss *Polytrichum* and the open seed capsule of the angiosperm *Portulaca*, considered as splash-cups, have several characteristics in common: the shape is that of a crucible or of a vase, the sides of which make an angle of 60°-70° with the horizontal; the diameter of the circular mouth is between 5 and 8 mm.; the cup matures in a vertical position. It has been demonstrated by Brodie (1) that, in each of these plants, heavy raindrops falling into the cups splash the contents to a distance of three feet or more, and experiments suggest that the structural features of splash-cups are related to the way in which these organs function. The existence of rain-operated mechanisms in so many kinds of very different plants indicates that this type of dispersal has a powerful survival value. The similarity of the splash-cups in different groups of plants affords a striking example of parallelism in the evolutionary process.

Details of structure of various rain-operated mechanisms have been described elsewhere and the manner of their operation has been explained by experiment and observation (1, 2, 3, 4, 5, 7, 8). The purpose of this paper is to summarize the facts most recently brought to light and to review the phenomenon of splash dispersal in plants as a whole. To this end, five different ways in which rain facilitates reproduction and dispersal in plants are recognized.

True Splash-cups

True splash-cups are now known in the fungi, lichens, liverworts, mosses, and seed plants (Brodie, 1, 4). In addition to the characteristics which the splash-cups of all these plants have in common, described above, true splash-cups operate in such a way that their spores or other reproductive structures are driven out by raindrops: in all examples, the cup is the producer as well as the dispenser of propagative units.

Splash-cups of fungi generally contain spores. The most elegant example of a fungus splash-cup is the fruit body of *Cyathus striatus* (Fig. 10). In this species and several other members of the Nidulariaceae, it has been demonstrated by Buller (7), Brodie (1, 5) and others that the lenticular peridioles containing basidiospores are ejected to distances up to seven feet. Adaptation to dispersal by rain has reached a remarkable degree of perfection: the little fruit body is firmly attached to the substrate by an emplacement of hyphae which prevents the cup from being dislodged by heavy raindrops; the inside surface of the cup is grooved or fluted and this feature is believed to break up the outgoing water drops, which occurrence results in the maximum lateral projection of the peridioles; the cup is highly resilient, a feature which prevents distortion by the battering of raindrops; and, perhaps most remarkable of all, the peridioles are provided with long cords by means of which they become attached to vegetation (Brodie 1, 5).

Spores smaller and more numerous than those of *Cyathus* are scattered by rain from the cups of *Polyporus conchifer.* The presence of cupulate structures on the upper side of the fruit body of this shelf-like polypore has long been known and recognized as a curious anomaly. It is now realized that the fungus begins its growth in the autumn as a cup developed on the upper side of a twig of elm (Brodie, 2). At this time, the inside of the cup produces minute spores or oidia embedded in a strongly hydrophilic gel which expands almost instantaneously when wetted. The cup is then filled with a concentrated suspension of oidia and the latter are splashed out by the first large raindrop landing in the fruit body (Fig. 6). Later in the season, hyphae grow from one side of the cup and form the typical bracket fruit body which bears pores on its lower side and liberates basidiospores (Fig. 7).

Two examples of fungi belonging to the Thelephoraceae are worthy of note. *Matula Rompelii* which is the asexual stage of *Cytidia habgallae* (Martin, 13) produces cups about 5 mm. in diameter, within which numerous chlamydospores are developed (Fig. 4). At the suggestion of Dr. G. W. Martin, this fungus was studied as a possible example of a splash mechanism. Although no living material was seen, and caution must be exercised in drawing conclusions from dead material, it was found that when the fungus was thoroughly wetted so that its rather matted contents became loosened, the contents were splashed from the cup by large water drops falling nine feet.

The ejection of a single projectile rather than of numerous spores is seen in *Aleurodiscus minnsiae* (Fig. 3). Each small, pink, hemispherical cup contains a single ball which is a sclerotium (Jackson, 11). The sclerotium, when planted on agar or on moist rotten wood, grows into mycelium. In nature, cups of *Aleurodiscus* grow only on the upper sides of hemlock twigs. When the cups are mature, heavy raindrops splash the sclerotium balls to a distance of about two feet.

Splash-cups in the lichens have not been studied extensively. However the striking resemblance between the vase-shaped podetia of *Cladonia* (Fig. 11) within which are borne soredia that serve for propagation and the vase-shaped fruit bodies of *Cyathus* (Fig. 10) is obvious. Soredia are, in fact, splashed from the cups of *Cladonia* (Brodie, 1) but rain is not the only natural force which disperses the soredia of this lichen. Brodie and Gregory (6) have shown that when the cup is dry it serves as a special organ from which wind scatters soredia. Clearly, the problem of the possible function of the various cupulate structures of lichens deserves more attention.

Among lower plants there are now recognized several in which gemmae are scattered by rain splash (Brodie, 1). The gemma cupules of *Marchantia polymorpha* are splash-cups from which the lenticular gemmae are readily disseminated by rain (Fig. 1, 2). Except for their small size, the gemma cupules resemble other splash-cups. Most textbooks of botany indicate that gemmae are "washed" away by rain. Few recount in detail that gemmae are thrown out forcibly as much as two feet as a result of their being developed in splash-cups, or that the gemmae themselves are coated with a hydrophilic colloid which doubtless enables them to withstand desiccation for some time and, by acting as a lubricant, facilitates their separation from one another and from the cupule.

The moss *Tetraphis* produces clustered gemmae partly enclosed within small leaf rosettes at the plant apices. Each leaf rosette is a splash-cup from which gemmae are dispersed by rain (Brodie, 1).

It is not surprising to find that gamete-producing structures of lower plants should occasionally represent adaptation to rain splash, especially in view of the importance of water in fertilization. Brodie (1) has shown that male gametes are thrown as much as two feet from the cupulate rosette of the male plant of the moss *Polytrichum* (Fig. 5). In the light of the notion that sperms are splashed upwards and outwards in a parabola to rain down upon the archegonia of female plants, the efficiency of reproduction of this moss becomes readily understood. Frequently sporophytes are found in great numbers on female plants two feet or more distant from male plants. If sperms had to swim down the male plants, along the ground for a distance of two feet and then up the female plants to the archegonia, it is doubtful that the females would develop sporophytes as regularly as observation shows they do.

Seed plants have developed splash-cups for seed dispersal to such an extent that it is difficult to understand why so little attention has been accorded to the subject. The fruits of the following plants vary somewhat in size of the cup and manner of operation, but all are efficient splash-cups: *Chrysoplenium spp., Mitella spp., Oenothera rosea* (Fig. 13), *Portulaca grandiflora* (Fig. 9), *P. oleracea, Sagina decumbens.* In each of these, seeds are thrown from the open fruits by raindrops. The capsule of *Oenothera rosea* remains closed when dry (Fig. 12) and opens by hygroscopic action when wet. The seeds can be dispersed only by rain unless the capsule should be broken open fortuitously by some animal or other agency.

These, in brief, are the true splash-cups of plants as we know them at present. There is little doubt that reflection and renewed observation will reveal many more when cup-shaped structures already well known are examined for evidence of rain splash mechanisms.

Springboard Mechanisms

A rain-operated mechanism of still another type is found among flowering plants. In what has been called the "springboard" mechanism (now recognized in eight species of flowering plants) a cupulate structure is developed but seeds are not ejected directly from the cup which serves only to catch a raindrop. The blow received by the cup sets in motion a springboard from which seeds are thrown.

Springboard dispersal has been described recently by Saville (16) in *Tiarella* (Saxifragaceae) and by Brodie (4) in *Salvia* (Fig. 14) and *Ocimum* (Labiatae) and other genera. Actually, this kind of dispersal was reported as early as 1936 by Nordhagen (15) and by Müller (14), but the writings of these two botanists appear to have been overlooked.

A modification of the seed-dispersing springboard is found in some succulent plants. In *Kalanchoë tubiflora* (Fig. 17, 18) cup-like plantlets develop on narrow outgrowths from the edge of the parent leaf. When water drops fall into the cup formed by the leaves of the plantlet, the force of the downward blow depresses the springboard to which the plantlet is attached. As the springboard returns to its normal position, it hurls the plantlet as much as five feet away (Brodie, 4).

Dispersal of the bulbils of the clubmosses *Lycopodium selago* and *L. lucidulum* (Fig. 19, 20, 21) is effected by a similar rain-operated mechanism. In 1901, F. E. Lloyd (12) drew attention to the fact that the bulbils of these plants are projected to a distance of three or four feet when they are depressed with the finger and then released. No one appears to have recognized heretofore that the bulbils and the plant parts to which they are attached constitute a rain-operated mechanism. The bulbil of *L. lucidulum* is, at maurity, held between two sets of short stiff modified leaves (Fig. 19, *a*, *b*) comprising a receptacle. The lowermost leaf of the receptacle (Fig. 19, *a*) is especially important in that it fits over an elongated swollen piece (Fig. 20, *a*) on the lower side of the bulbil. The receptacle clasps the bulbil at its base under tension which, when released, serves to propel the bulbil. The most obvious naturally occurring force necessary to set off the mechanism is that of a large raindrop. The distal portion of the bulbil is a broad thin spatulate piece, hollowed out or depressed at the broad end (Fig. 19, *c*).

This extension catches a raindrop and the downward blow releases the bulbil from the stiff leaves that hold it, with the result that the bulbil springs from the parent plant. I had studied this apparatus carefully in 1953 and felt certain that it represented the first rain-operated device to be recognized among the clubmosses. Recently, Professor C. T. Ingold has reported observations which confirm my own entirely. With his permission, I quote from his letter to me (April 6, 1956):

"On allowing large drops of water to fall from a height of several feet on to *Lycopodium selago*, I found that when a drop registered a direct hit the bulbil was discharged to a distance of several inches."

Without undue emphasis, it is interesting to note the strong resemblance between the calyx tube and the pedicel of the angiosperm *Salvia lyrata* (Fig. 14) which together serve as a springboard mechanism for seed dispersal by rain, and the bulbil and receptacle of the clubmoss *Lycopodium lucidulum* (Fig. 19) !

Rain-induced Puffing

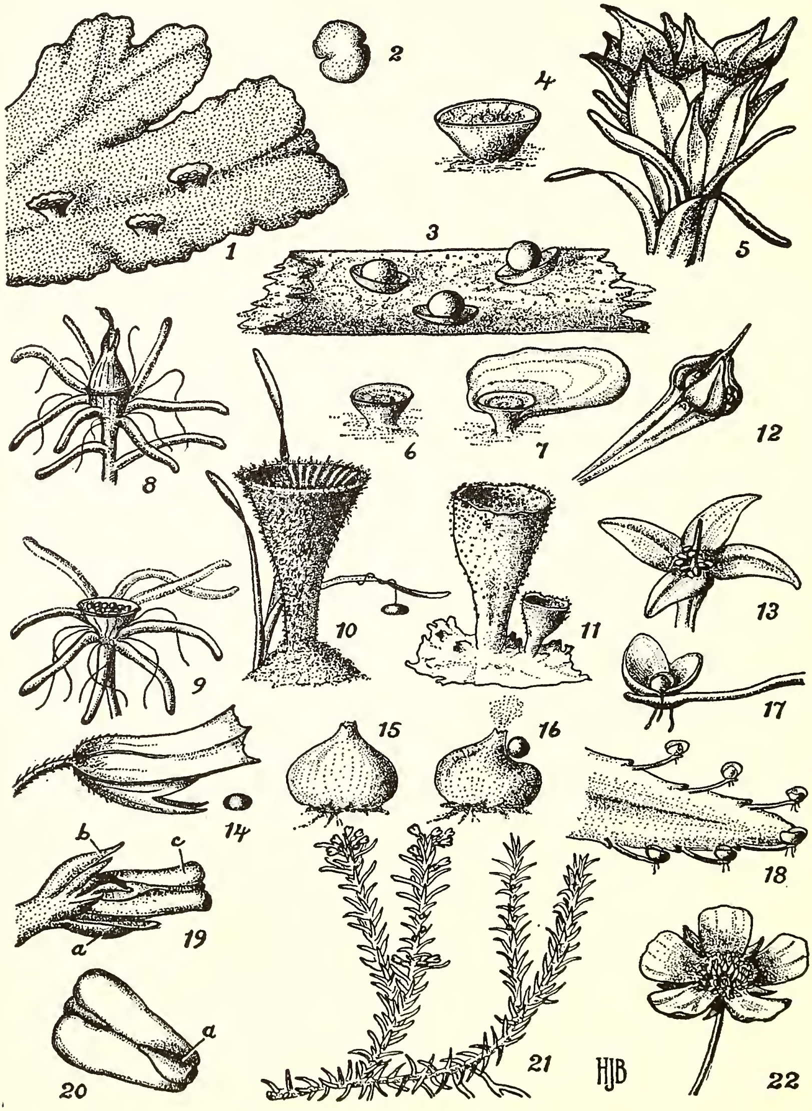
Puffballs, earthstars and similar fungi are generally supposed to discharge their powdery spores by the action of wind passing over the apical opening (ostiole) or entering the fruit body through holes in the side of the papery endoperidium and passing out through the ostiole as out of a chimney. In 1949 Gregory (8) proved that wind of ordinary speed is not effective in removing spores from puffballs. Spores can be discharged occasionally from puffballs as a result of blows received accidentally from the feet of large animals, but such occurrences cannot be very frequent. In a series of beautiful experiments, Gregory showed that the discharge of spores of *Lycoperdon perlatum* (Fig. 15, 16), *L. pyriforme* and *Geaster umbillicatus* is brought about by the impact of water drops with the papery top of the endoperidium. By means of high-speed photography, he demonstrated that when a raindrop depresses the endoperidium, air and spores are ejected through the ostiole of the fungus. To date, the fungi mentioned are the only examples of this kind of dispersal that have been studied. Careful examination of thin-walled ball-shaped structures in other plants might well prove profitable.

Grout's observation (Mosses with a Handlens, 1903, p. 71) that spores are puffed from the capsule of the moss *Diphyscium* by the battering of raindrops suggests the same kind of mechanism as that which operates in *Lycoperdon*.

Rain-splash Pollination

Because of the common observation that pollen grains or the pollen tubes developed from them burst in water as a result of the concentration of the contents and consequent absorption of water, little thought has been given to the possible role of rain as an agency of pollination of land inhabiting plants. An objection to rain pollination often raised is that, in many plants, pollen is protected from contact with rain by floral structure.

True, the pollen of many plants is adversely affected by rain; the interesting facts remain, however, that the pollen of some plants at least germinates readily in rain water and that rain is the chief agency of pollination for some flowers. In 1950, Hagerup (10) showed that when raindrops land in the stiff cup-shaped flowers of some species of *Ranunculus* (Fig. 22), *Caltha* and *Narthecium*, splash action carries pollen from anthers to stigmas. In fact, Hagerup showed that seeds are not set by the plants he studied unless the flowers are subjected



Description of Illustrations

Fig. 1. Gemma cupule on the thallus of *Marchantia polymorpha.* x 3.
Fig. 2. Gemma of *Marchantia polymorpha.* x 25.
Fig. 3. Splash-cups of *Aleurodiscus minnsiae* with sclerotial balls. x 12.
Fig. 4. Splash-cup of *Matula Rompelii.* x 4.
Fig. 5. Rosette of male plant of *Polytrichum juniperinum.* x 10.
Fig. 6. Young slash-cup of *Polyporus conchifer.* x 2.
Fig. 7. Mature fruit body of *Polyporus conchifer.* x 2.
Fig. 8. Unopened fruit of *Portulaca grandiflora.* x 1.5.
Fig. 9. Open fruit of *Portulaca grandiflora,* showing cupulate form and seeds within. x 1.5.
Fig. 10. Slash-cup of *Cyathus stiatus.* x 2.5.
Fig. 11. Podtium of the lichen *Cladonia pyxidata.* x 2.5.
Fig. 12. Capsule of *Oenothera rosea, dry.* x 2.
Fig. 13. Capsule of *Oenothera rosea* which has opened on being wetted. x 2.
Fig. 14. Calyx of *Salvia lyrata,* showing nutlet being ejected by springboard action. x 2.
Fig. 15. Puffball, *Lycoperdon perlatum.* x 1/5.
Fig. 16. Raindrop striking fruit body of *Lycoperdon perlatum* and spores being puffed out. x 1/5.
Fig. 17. Plantlet of *Kalanchoe tubiflora* attached to outgrowth from leaf x 2.5.
Fig. 18. Tip of leaf of *Kalanchoe tubiflora showing plantlets.* x 1.
Fig. 19. Bulbil of *Lycopodium lucidulum* showing attachment: *a,* lower modified leaf which clasps bulbil on lower side; *b,* upper clasping modified leaves; *c,* concave part of bulbil. x 3.5.
Fig. 20. Under side of bulbil of *Lycopodium lucidulum* showing projection *a* which fits into modified leaf shown in Fig. 19 *a.* x 4.
Fig. 21. *Lycopodium lucidulum* with bulbils. x 1/2.
Fig. 22. *Ranunculus sp.,* a cup from which pollen is splashed by rain. x 1.5.

to rain. Hagerup's observations become doubly important when it is realized not merely that rain effects self pollination of the flowers but also that, through splash action, pollen from one flower cup may be thrown out to land on another and thus ensure cross pollination. And it may be that rain is a more important agency of pollination that would be supposed on the basis of Hagerup's observations dealing with a small number of species of plants.

Raindrops and the Dispersal of Curved Spores

The work of allergists and plant pathologists has produced a large amount of information concerning the dispersal of spores, pollen grains and other particles in the air. Students of aerobiology have a fairly accurate picture of what happens and may be expected to happen when dry spores and pollen grains are freed into the atmosphere to be carried by wind currents and scattered by air turbulence.

The distribution of certain kinds of spores remains anomalous. These exceptions are found mostly among fungi whose spores are developed in glutinous masses or, for some other reason, are not liberated except when wet. For these, there is some evidence (Gregory, 9) that the pattern of dispersal is different from that of most spores scattered in dry air. This may be because rain is the dispersal agent. Investigators who study the air flora by allowing microorganisms to collect on slides or in Petri plates exposed to the air often notice that minute water droplets (deposited from fog, mist, etc.) enclose fungus spores. Such spores are, more commonly than not, of the hyaline curved type, such as those of *Fusarium* and a number of other genera. The significance of this observation is not known with certainty. However, Gregory has suggested that many kinds of spores dispersed only during wet weather may be carried by very small water droplets. If droplets from mist or a drizzling rain bounce on to the surface of a leaf or other substrate on which spores like those of *Fusarium* are being developed, it is quite possible that the droplets may pick up spores and bounce away. Why curved spores would be more readily picked up by droplets than spores of other form, is unknown; it may be related to surface tension effects. Although no experimental work on this problem has been done, the evidence available suggests that raindrops may play a role as carriers of microorganisms the importance of which has been underestimated.

Summary

1. Raindrops bring about the dispersal of gametes, spores, seeds, and other kinds of reproductive units in a great variety of plants. Over thirty rain-operated dispersal mechanisms are recognized, scattered throughout almost all groups of plants.

2. Special organs called "splash-cups" are produced by fungi, lichens, liverworts, mosses and seed plants. A typical splash-cup is 5-8 mm. wide at the mouth, is vase-shaped or crucible-shaped, has sides which make an angle of 60°-70° with the horizontal and matures in a vertical position. Raindrops splash peridioles from the fruit bodies of the fungus *Cyathus* and of other fungi, sperms from the cupulate male plant rosettes of the moss *Polytrichum* and of other mosses, and seeds from the open seed capsules of such angiosperms as *Portulaca*.

3. In certain flowering plants, such as *Salvia lyrata*, rain operates a "springboard" device. The calyx tube of *Salvia* produces a kind of cup which catches raindrops. The blow received by the cup depresses the calyx tube and, when the latter springs back into normal position, fruits are thrown from the calyx tube. The plantlets of *Kalanchoë tubiflora* are dispersed by a similar springboard action. The bulbils of *Lycopodium selago* and *L. lucidulum* are shown, for the first time, to be dispersed by a rain-operated mechanism of the springboard type.

4. The discharge of spores from puffballs is brought about by the impact of water drops with the papery top of the endoperidium.

5. The pollination of some cup-shaped flowers such as those of certain species of *Ranunculus*, *Caltha* and *Narthecium* is brought about by the splashing action of raindrops.

6. Many kinds of curved fungus spores, not ordinarily dispersed during dry weather, may be carried by minute water droplets which strike a spore-laden surface and bounce away taking spores with them.

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The Use of Celloidin for the Study of Leaf Surfaces

Joe Dunkin and S. N. Postlethwait, Purdue University

The shapes, sizes, and arrangement of epidermal cells of plant leaves are consistent enough that they can be used in a limited way in classification. However, preparation of paradermal sections of leaves by the paraffin method entails considerable time and difficulty in obtaining a usable section. Transectioning by hand or stripping the epidermis also is laborious and unrewarding in the production of good sections.

A technique, which employs the use of celloidin, has been developed which reveals in detail the size and shape of the epidermal cells. The locations of the stomata are easily observed as well as their position in relation to the other epidermal cells (figs. 1-6). The technique is valuable for quick, easy stomatal counts. Another advantage is that these celloidin peels can be indexed and stored, allowing the examination to be conducted at a later date. Also, the leaves need not be killed, fixed, or embedded in paraffin. Some plants can be used, such as *Zea mays*, without harming the leaves. On other plants, such as soybean, the celloidin penetrates the leaf thereby destroying it, but the plant itself is unharmed.

Leaves to be studied must be clean. Cleaning can be accomplished in one of two ways. The leaf can be brushed with a camel's hair brush, or a thin coat of celloidin can be applied, allowed to dry, then pulled off and discarded. The thick waxy cuticle of some plants, such as banana, may have to be removed by lightly scraping with a razor blade. Care must be taken to prevent injury to the epidermis.

After the leaf is cleaned, a thin coat of celloidin is applied with a camel's hair brush. This celloidin is allowed to dry completely and then is pulled off. Better detail is obtained by using thin sections. The results, for some purposes, are equivalent, if not superior, to paradermal sections prepared by the paraffin technique.

This technique has some disadvantages. Sometimes it is impossible to obtain a microscopic field that is entirely in focus. This is caused either by curvature of the leaf itself or by curvature in the celloidin as it is pulled off. Even though this prevents a photomicrograph from being entirely in focus, (fig. 5), one can observe the shapes and structures of the epidermal cells and stomata counts can be made by adjusting the focus with the fine adjustment knob.

Another disadvantage is encountered when using leaves which have sunken stomata (fig. 2). The depression above the stoma causes holes to form in the celloidin that appear as black spots in the photograph. Even though no details are recorded the number of stomata per unit area can easily be counted and some estimation of size can be made.

Journal Paper N. 1057, Agricultural Experiment Station, Purdue University.

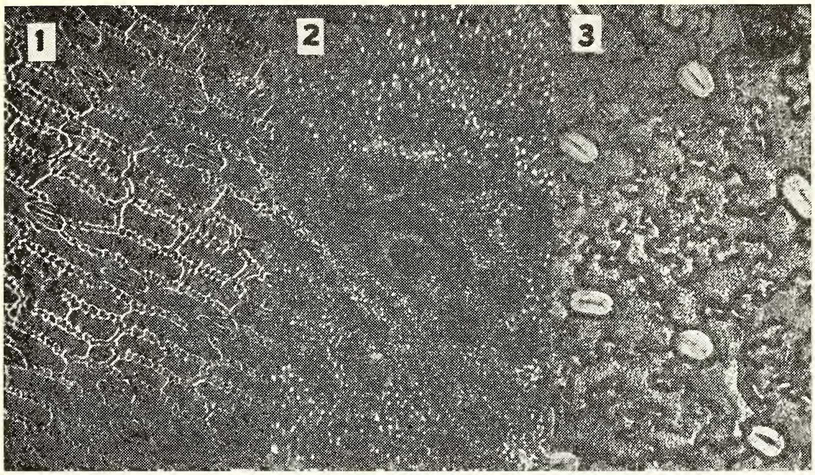


PLATE I

All photomicrographs are of abaxil surfaces unless stated otherwise, and are reproduced at approximately 200 X

1. *Zea mays:* Stomata appear clearly as do the wave-like structure of the cell walls.
2. *Tsuga canadensis:* Black spots are holes in the celloidin caused by the sunken stomata.
3. *Onoclea sensibilius:* Note the irregularity of cell shape.

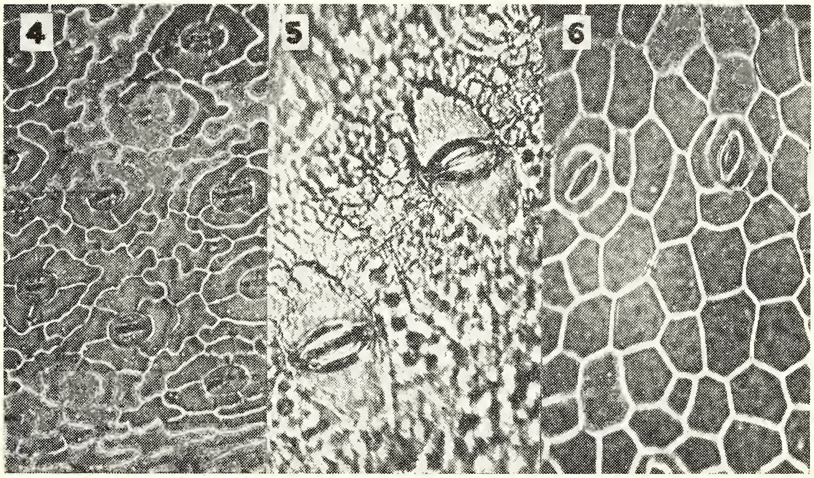


PLATE II

4. *Nephrolepis exaltala:* (var. bostoniensis) The number of subsidiary cells vary from two to four.
5. *Dioscorea:* The extremely large stomata are seen while the other epidermal cells are not clearly distinguishable.
6. *Crassula arborescens:* Adaxil surface. Note regular symmetry of epidermal cells.

The same problem of focus occurs with leaves which have raised stomata. If the focus is made on the epidermal cells, the stomata will appear out of focus. If the focus is made on the stomata, the epidermal cells will appear out of focus. However, this presents no real problem, the solution being to take two photographs, one at each focus.

This technique was developed to determine stomatal numbers in dwarf and normal *Zea mays*. Using this technique a large number of leaf surfaces were counted with a minimum of time and effort. Other information was obtained at the same time, such as the relative size of both the stomata and epidermal cells, and whether or not the stoma were opened or closed.

Studies involving ploidy, leaf ontogeny, classification, and comparison of hybrids may be supplemented by this technique.

CHEMISTRY

Chairman: Donald J. Cook, DePauw University
Robert B. Fischer, Indiana University, was elected chairman for 1957

ABSTRACTS

The Structure of Glucagon. W. W. Bromer, L. G. Sinn, A. Staub and Otto K. Behrens, Lilly Research Laboratories, Indianapolis, Indiana.—Investigations leading to formulation of the amino acid sequence of glucagon were undertaken.

Quantitative amino acid analysis of glucagon provided evidence for the following empirical formula with 29 amino acid residues, and with a minimum molecular weight of 3485: $His_1Ser_4Glu_3Gly_1Thr_3Phe_2Asp_4Tyr_2Lys_1Leu_2Arg_2Ala_1Val_1Try_1Met_1(—CONH_2)_4$. Histidine was determined as the N-terminal amino acid by means of the dinitrophenylation method; the C-terminal residue is threonine on the basis of data obtained from hydrazinolysis and carboxypeptidase treatment. Carboxypeptidase quantitatively liberated the following amino acids from the C-terminus of glucagon: valine, glutamine, tryptophan, leucine, methionine, asparagine, and threonine. A small amount of alanine and somewhat greater quantities of phenylalanine, aspartic acid, and a second residue of glutamine were also released.

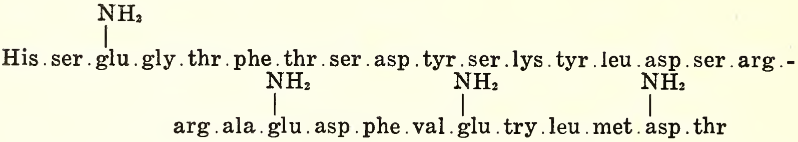
A single lot of carefully purified crystalline glucagon was used throughout the structure studies. The methods employed in the structure determination were as follows: (a) specific enzymatic cleavage with trypsin, chymotrypsin, and subtilisin; (b) resolution of the peptides from these digestions using Dowex 50 chromatography; and (c) characterization of the peptides by quantitative amino acid analysis, dinitrophenylation, and in some cases further degradation with carboxypeptidase and acid.

Dowex 50 chromatography of the chymotryptic digest resulted in the separation of six pure peptide fragments. Five fragments were isolated from a 2¼ hour tryptic digestion of glucagon, and seven peptides were obtained from a 50-hour trypsin incubation. Subtilisin digestion followed by chromatographic resolution gave eleven peptides.

In a great majority of cases specific enzymatic splits of greater than 80% were obtained and the resulting peptides were isolated in yields exceeding 50%. With every enzyme used, the sum of the resulting fragments was in complete agreement with the empirical formula of glucagon.

The structure of four peptides was elucidated by partial acid degradation and carboxypeptidase treatment. The locations of the four amide linkages were determined by subjecting selected peptide fragments to chemical analysis.

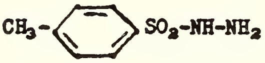
Integration of these data provides a basis for the complete amino acid sequence of glucagon:



$$\text{His.ser.}\overset{\displaystyle NH_2}{\overset{|}{\text{glu}}}\text{.gly.thr.phe.thr.ser.asp.tyr.ser.lys.tyr.leu.asp.ser.arg.-}$$

$$\text{arg.ala.}\overset{\displaystyle NH_2}{\overset{|}{\text{glu}}}\text{.asp.phe.val.}\overset{\displaystyle NH_2}{\overset{|}{\text{glu}}}\text{.try.leu.met.}\overset{\displaystyle NH_2}{\overset{|}{\text{asp}}}\text{.thr}$$

p-Toluenesulfonylhydrazide and Its Decomposition Products. JOHN H. BILLMAN, S. D. PARFIT and IRA A. MURPHY, Indiana University.—During the course of another investigation it was found that if p-toluenesulfonylhydrazide (I) was heated with phenol and benzoyl peroxide in a carbon tetrachloride solution, a mixture of N,N′-di(p-toluenesulfonyl)-hydrazide (II) and p-tolyl p-toluenethiosulfonate were formed.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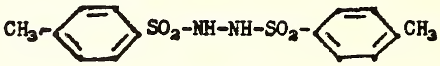
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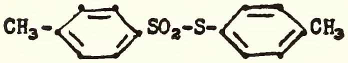
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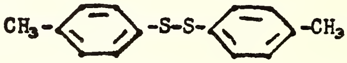
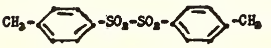

IV

The former product (II) was also isolated when p-toluenesulfonylhydrazide (I) was heated with benzoyl peroxide alone in carbon tetrachloride. It seemed reasonable to suppose that during the formation of (II) hydrazine was liberated which then reduced the p-tolyldisulfone  (V) which might be formed as an intermediate.

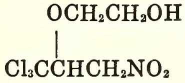
When p-toluenesulfonylhydrazide (I) was refluxed alone in toluene solution for 24 hours a lower melting compound was isolated. This proved to be p-tolyldisulfide (IV). Again it was supposed that hydrazine acted as the reducing agent.

Indeed it was found that when the thiolester (III) was heated with 85% hydrazine hydrate in toluene solution the disulfide (IV) was formed. It must be pointed out, however, that this reaction might not proceed by straight forward reduction but could occur by splitting of the molecule to give the disulfide and also the disulfone. Only a very high yield of the disulfide would prove conclusively that reduction took place but in consideration of the previous reactions which could only involve reduction of some sort, it seems very probable that this is the mechanism of this reaction also.

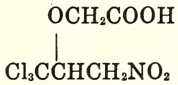
Contribution No. 756 from the Chemical Laboratories of Indiana University.

Further work is being carried out on these reactions and a study of the generality of this method and the possibility of reducing sulfonic acids directly is being made.

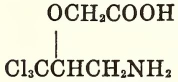
Heterocyclic Compounds via 1,1,1-trichloro-3-nitropropanol. HOWARD BURKETT and GUNNER NELSON, DePauw University.—The purpose of this research was to investigate several possible approaches to the synthesis of various types of heterocyclic compounds using 1,1,1-trichloro-3-nitropropanol as the initial starting material. During the course of this study the following new compounds were prepared.



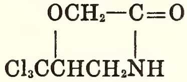
$\begin{array}{l} \quad OCH_2CH_2OH \\ \quad | \\ Cl_3CCHCH_2NO_2 \end{array}$



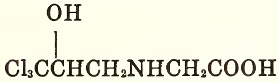
$\begin{array}{l} \quad OCH_2COOH \\ \quad | \\ Cl_3CCHCH_2NO_2 \end{array}$



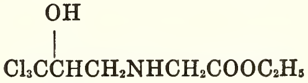
$\begin{array}{l} \quad OCH_2COOH \\ \quad | \\ Cl_3CCHCH_2NH_2 \end{array}$



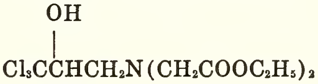
$\begin{array}{l} \quad OCH_2-C=O \\ \quad | \qquad\quad | \\ Cl_3CCHCH_2NH \end{array}$



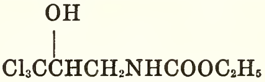
$\begin{array}{l} \quad OH \\ \quad | \\ Cl_3CCHCH_2NHCH_2COOH \end{array}$



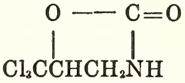
$\begin{array}{l} \quad OH \\ \quad | \\ Cl_3CCHCH_2NHCH_2COOC_2H_5 \end{array}$



$\begin{array}{l} \quad OH \\ \quad | \\ Cl_3CCHCH_2N(CH_2COOC_2H_5)_2 \end{array}$



$\begin{array}{l} \quad OH \\ \quad | \\ Cl_3CCHCH_2NHCOOC_2H_5 \end{array}$



$\begin{array}{l} \quad O - C=O \\ \quad | \qquad | \\ Cl_3CCHCH_2NH \end{array}$

This research is being continued.

An Improved Procedure for the Preparation of Aromatic Thiols. E. CAMPAIGNE and S. W. OSBORN, Chemistry Department, Indiana University.—The preparation of aromatic thiols from the corresponding aryl ethyl xanthates by alkaline hydrolysis has not been satisfactory in many instances. Yields are relatively low due to loss by oxidation, and to incomplete hydrolysis in the case of hindered xanthates. Although Tarbell and Fukushima report yields of 63-75% in the case of *m*-tolyl ethyl xanthate, we have been unable to duplicate these yields with more hindered compounds. In our hands the conventional method gave at best a yield of only 49% in the case of 2,6-dimethylthiophenol, and even poorer yields in the case of *o*-thiocresol (39%) and *o*-phenylthiophenol (21%).

Following the suggestion of Djerassi, reduction of the xanthates by lithium aluminum hydride proved to be a much more effective method for preparing hindered aromatic thiols. Yields of 84-89% were consistently obtained. For example, reduction, of *o*-biphenyl ethyl xanthate with lithium aluminum hydride gave an 84% yield of pure *o*-phenylthiophenol, while even better yields were obtained in the preparation of 2,6-dimethylthiophenol (86%) and *o*-thiocresol (89%) by the reduction of their respective xanthates.

The two new compounds, *o*-phenylthiophenol and 2,6-dimethylthiophenol have been characterized and derivatives prepared.

Studies on the Bromination of Carbostyrils. D. J. COOK, PETER SORTER and R. S. YUNGHANS, DePauw University.—This work involves a study of the products obtained when several methyl substituted carbostyrils were brominated by use of N-bromosuccinimid.

When 1,4-dimethylcarbostyril is treated with N-bromosuccinimid, the bromine appears to substitute in the 3-position of the heterocyclic ring. A similar study with 4-methylcarbostyril finds the bromine substituting for a hydrogen in the 4-methyl group. It appears that when a methyl group is attached to the nitrogen of the ring, substitution is preferential in the open 3-position of the ring while bromine will substitute for a hydrogen in the 4-methyl group if no substituent appears on the nitrogen.

When position 3 of the hetero ring is covered with a methyl group, as found in 1,3,4-trimethylcarbostyril, bromination with N-bromosuccinimid results in bromine entering the 3-methyl position. A bromination of N-methyl-α-methylacetoacetanilide with bromine in chloroform and then ring closurer of the intermediate with concentrated sulfuric acid, yielded a product believed to be 1,3-dimethyl-4-bromoethylcarbostyril. The difference between this compound and the previous mentioned one was used as evidence for the substitution in the 3-methyl group.

In a number of instances the infra-red absorption spectra were helpful in determining the position of bromine substitution.

Analysis by Extraction and High Frequency Measurement

ROBERT B. FISCHER and SAMAK KOSOLSOMBAT,[1] Indiana University

The usefulness of radio frequency measurements in quantitative analysis has been under investigation in several laboratories for about ten years. Numerous reports have been made on instrumental design, theory and application. Some of the applications have involved titrations, and others have been direct determinations of concentration.

The purpose of this study was to investigate the usefulness of this type of measurement in direct determinations of concentration following extraction of an inorganic substance in an organic liquid. Two specific determinations were selected, the determination of lithium chloride in mixtures with sodium chloride, and the determination of calcium nitrate in mixtures with strontium nitrate. Both determinations are difficult by ordinary chemical methods because of the close chemical similarity between the two substances in each case.

Experimental

A model V Sargent oscillometer was used for all high frequency measurements. The readings are, in effect, in empirical units of capacitance.

For each of the two systems, a series of weighed portions of the substance to be determined was prepared, a portion of the organic liquid was added by pipet, the mixture was shaken until dissolution was complete, and a reading was taken on a portion of the liquid. From these data a calibration curve was prepared. Then a series of standard mixtures was prepared, the organic liquid added, the mixture shaken, and a reading made on a portion of the clear supernatant liquid. For each of the latter readings, the amount of desired substance was read off the calibration curve and compared with the amount used in preparing each sample. All readings were corrected to a fixed temperature, 25° C., by means of empirically determined correction data.

1. Determination of lithium chloride in mixtures with sodium chloride.

The organic liquid selected to extract lithium chloride was 2-ethyl hexanol. The listed solubilities (gram per 100 ml.) for some alkali chlorides in 2-ethyl hexanol are: Li Cl, 3.0; Na Cl, 0.0001; K Cl, less than 0.00001 (2). Batches of the solvent were purified prior to use by two fractional distillations, collecting the fraction distilling at 184-185° C. Reagent grade lithium chloride and sodium chloride were used, each being dried at 110° C. for 12 hours and stored in a desiccator.

The effect of temperature variation upon the scale reading for the pure solvent was determined by direct experiment. The scale reading decreases by about 57 units per degree C. increase in temperature. The temperature dependence of solutions of lithium chloride in 2-ethyl hexanol appeared to be about the same, so an additive or subtractive correction was made upon all subsequent readings to correct them to 25° C.

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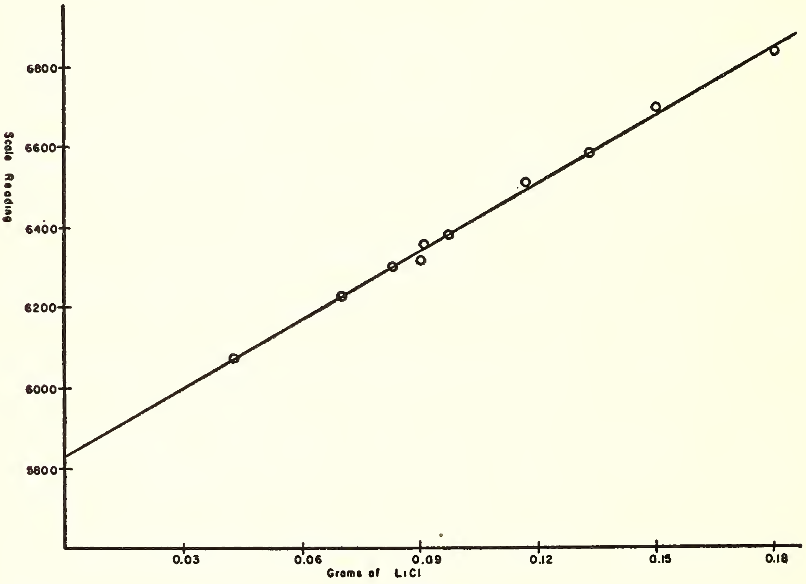
In obtaining data for the calibration curve, a 25-ml. portion of the organic liquid was used for each sample, and a 10-ml. portion of this was used for the reading. About three hours were required for complete dissolution of the lithium chloride. The calibration curve is shown in figure 1. With larger amounts of lithium chloride, the curve levelled off and above about 0.5 gram, actually reversed its slope, so the linear portion shown in figure 1 was used.

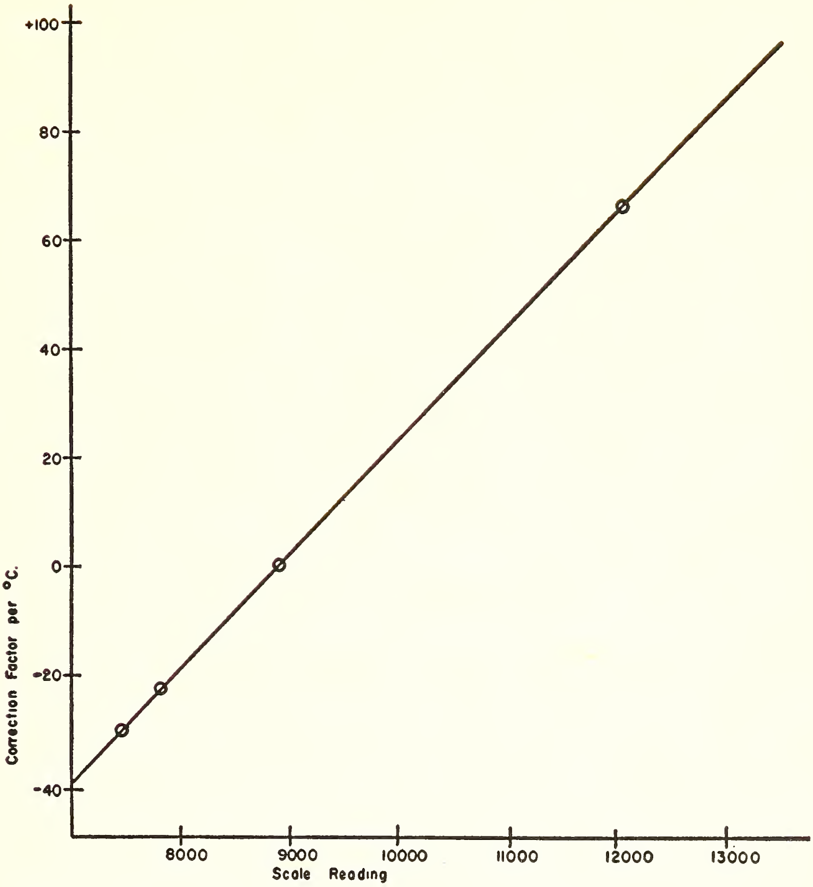


Calibration Curve for Determination of Lithium Chloride

Mixtures of lithium chloride and sodium chloride were prepared, and the amount of lithium chloride in each was determined, by extraction and measurement, with the aid of the calibration curve. Comparative data on the amounts "taken" and "found" are listed in table 1. The standard deviation of an individual result is about 0.0013 gram lithium chloride per 25 ml. of 2-ethyl hexanol, which corresponds to about 3.% of the smallest amount of lithium chloride and to about 0.9% of the largest amount.

2. Determination of calcium nitrate in mixtures with strontium nitrate.

The extracting liquid selected was butyl cellosolve, in which some listed solubilities (gram per ml.) are: Ca $(NO_3)_2$, 0.243; Na NO_3, not more than 1.1×10^{-5}; Ba $(NO_3)_2$, not more than 2.3×10^{-6} (1). This solvent was also purified by double fractional distillation, retaining the portion distilling at 171-172° C. Reagent grade calcium nitrate and

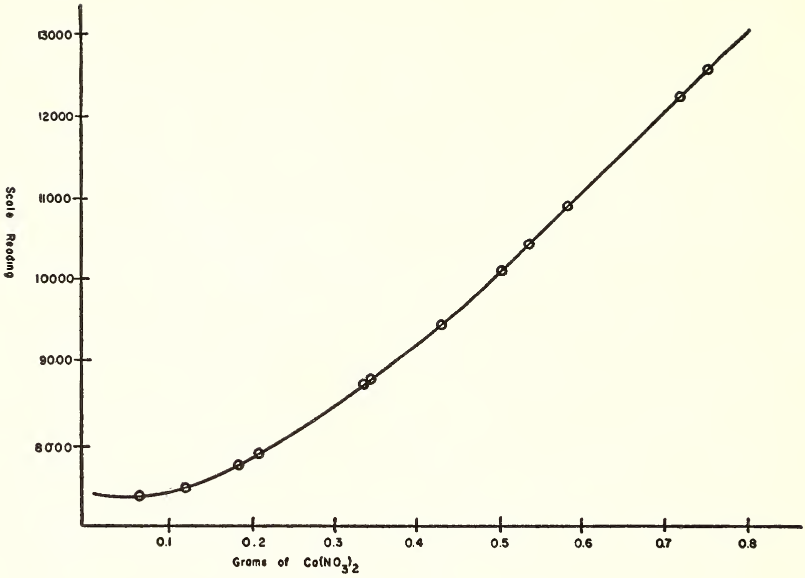


Temperature Correction Curve for Determination of $Ca(NO_3)_2$

strontium nitrate were used, the latter after drying at 110° C. for 12 hours. It was necessary to make the calcium nitrate anhydrous by heating at about 175° C. for 30 hours—determination of calcium by a conventional procedure revealed that this material was then stoichiometrically in the anhydrous form.

The effect of temperature variation upon scale reading was found to differ for the solvent and for solutions. The temperature data are summarized in table 2 and plotted in figure 2. A minus sign means that a temperature increase causes a decrease in the scale reading. With the aid of figure 2, all subsequent readings were corrected to 25° C.

In obtaining the data for the calibration curve, it was found that 45 minutes shaking time sufficed, with 25-ml. portions of the butyl



Calibration Curve for Determination of $Ca(NO_3)_2$

cellosolve and with amounts of calcium nitrate ranging from about 0.1 gram to 2.7 gram. The calibration data are plotted in figure 3.

Mixtures of calcium nitrate and strontium nitrate were prepared by direct weight, and the amount of calcium nitrate in each was determined, by extraction and measurement, with the aid of the calibration curve. Comparative data on the amounts "taken" and "found" are listed in table 3. The standard deviation of an individual result is 0.0041 gram calcium nitrate, which corresponds to from 4.5% to 0.4% of the amount of calcium nitrate taken.

Conclusion

It has been shown that lithium chloride can be determined in mixtures with sodium chloride with a standard deviation of 3.0 to 0.9 parts per hundred over the range of 0.04 to 0.14 gram lithium chloride by extraction with 2-ethyl hexanol and high frequency measurement and that calcium nitrate can be determined in mixtures with strontium nitrate with a standard deviation of 4.5 to 0.4 parts per hundred over the range of 0.09 to 0.90 gram calcium nitrate by extraction with butyl cellosolve and high frequency measurement. The extraction step is quite time-consuming, but the final measurements are quite rapid after the necessary calibration data are obtained. It is felt that the accuracy and precision in these experiments are limited primarily by residual irreproducibility of the instrument used. It is further felt that the method of high frequency measurement would be applicable in other analytical determinations in conjunction with the extraction method of separating the desired substance.

TABLE 1. Results of Determinations of Lithium Chloride in Mixtures with Sodium Chloride.

g Na Cl taken	g Li Cl taken	g Li Cl found	difference
0.1319	0.0419	0.0419	±0.0000
0.1676	0.0570	0.0580	+0.0010
0.1114	0.0790	0.0775	—0.0015
0.1211	0.0831	0.0811	—0.0020
0.1316	0.0835	0.0840	+0.0005
0.1225	0.0906	0.0899	—0.0007
0.1133	0.1000	0.1019	+0.0019
0.1271	0.1069	0.1080	+0.0011
0.1337	0.1081	0.1092	+0.0011
0.1491	0.1383	0.1374	—0.0009

TABLE 2. Effect of Temperature Variation Upon Scale Reading.

g $Ca(NO_3)_2$/25 ml. solvent	Scale reading @ 25° C.	Change of scale reading per degree C.
0.0000	7469	—29
0.1726	7711	—21
0.3621	8953	+0
0.6197	11196	+66

TABLE 3. Results of Determinations of Calcium Nitrate in Mixtures with Strontium Nitrate.

g $Sr(NO_3)_2$ taken	g $Ca(NO_3)_2$ taken	g $Ca(NO_3)_2$ found	difference
0.3580	0.0901	0.0980	+0.0079
0.2460	0.1403	0.1382	—0.0021
0.1826	0.2376	0.2359	—0.0017
0.3990	0.3078	0.3049	—0.0029
0.2412	0.3855	0.3888	+0.0033
0.1750	0.4401	0.4435	+0.0034
0.2707	0.4418	0.4409	—0.0009
0.2770	0.5433	0.5430	+0.0003
0.2162	0.5735	0.5810	+0.0075
0.2621	0.6912	0.6872	—0.0040
0.2344	0.8476	0.8481	+0.0005
0.2042	0.9060	0.9095	+0.0035

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Acidity of Trichloroacetic Acid

HOWARD BURKETT, RICHARD MURPHY and DEAN YARIAN,
DePauw University

Authors of numerous textbooks state that trichloroacetic acid is a strong acid—comparable to the strong mineral acids. This statement is correct for dilute aqueous solutions. In addition to other evidence measurements of the Hammett acidity function[1] showed that the acidity function, H_o,

$$H_o = pK_a + \log([B] / [BH^+]) \quad (1)$$

of trichloroacetic acid was almost identical with that of the strong mineral acids in dilute solutions. At concentrations above about twenty percent, however, the acidity function did not increase further but remained constant with increasing acid concentration. The maximum value of the acidity function was reported to be approximately +0.60.

Two observations would lead one to question this low value for the acidity of trichloroacetic acid. First, comparison of the rates for the hydrolysis of sucrose vs. the acidity function for various acids (2) shows that trichloroacetic acid appears to be a much better catalyst than the mineral acids. If the rate constants vs. molar concentration (rather than vs. acidity function) are plotted, the curve for trichloroacetic acid deviates no more from the mineral acids than the mineral acids deviate from each other. If catalytic action is proportional to acidity function, as was proposed for the mineral acids, it seems likely that the measurements of the acidity functions were in error. That only one indicator was used in this study made this possibility of error more plausible.

Second, cryoscopic measurements (3) show that trichloroacetic acid is unionized (as a base) in pure sulfuric acid. On the other hand, weak to moderately strong acids (acetic, chloroacetic, dichloroacetic, nitric and hydrochloric acids, for example) do ionize as bases in sulfuric acid. The stronger acids ionize less than the weaker ones. Perchloric acid, a very strong acid, does not so ionize. It has been proposed that the greater the acid strength of an acid the lower will be its basicity toward sulfuric acid. If this correlation is valid for all acids, trichloroacetic acid should be approximately as strong as perchloric acid.

The authors considered the possibility that trichloroacetic acid could form a strong dimeric association complex (as does acetic acid) in the more concentrated solutions, which would lower its effectiveness as a proton donor (acid). Gillette (4) concludes, from shifts of the infrared absorption band near 1721 $cm.^{-1}$, that association is considerably decreased in the series alkylacetic, acetic, chloroacetic, dichloroacetic and trichloroacetic acids. Moreover, dipole moment studies (5) and vapor density measurements (6) indicate the order of decreasing association to be alkylacetic, acetic and chloroacetic acid. Although no quantitative estimation can be made of the degree of association, these experiments suggest that dimeric association is an unlikely cause for the low acidity of trichloroacetic acid.

In addition, conductimetric measurements (7) of concentrated solutions of acids in acetic acid indicated trifluoroacetic acid to be a stronger acid that nitric acid. It is to be noted, of course, that these studies were for trifluoroacetic acid (not trichloroacetic acid) and in the solvent acetic acid rather than water.

For the reasons indicated above, a reinvestigation of the acidity of concentrated solutions of trichloroacetic acid was considered to be desirable.

Experimental

Materials. The nitrogen indicators, o-nitroaniline, p-nitroaniline and 2-chloro-4-nitroaniline, were obtained from commercial sources. They were recrystallized from alcohol-water mixtures until no further rise in melting point was obtained, then recrystallized one more time. Final drying was in a desiccator over phosphorous pentoxide. The 2,4,6-trimethoxybenzaldehyde was prepared by a published method (8). It was carefully recrystallized and dried in the same manner as the nitrogen indicators. Concentrations of the acid solutions were determined by titrating weighed samples.

Procedure. For each measurement a weighed sample of the indicator was dissolved in the solvent acid in a volumetric flask so that the resluting solution was 10^{-4} to 10^{-5} molar. The ultra violet spectrum was determined using the Beckmann D U instrument. Duplicate measurements were made in every case including the preparation of the solution. The extinction coefficients were calculated and plotted vs. the wavelength. For each indicator the spectrum in water was considered to be the spectrum of the unionized indicator. Since ionization was not complete in any concentration of the trichloroacetic acid solutions, the spectrum in a suitably high concentration of sulfuric or perchloric acid was used for the spectrum of the conjugate acid (complete ionization) of each indicator.

Calculation of the ratio of base to conjugate acid of the base were made at several wavelengths near the absorption maximum of the unionized base, using the equation

$$[B]/[BH^+] = (E_B - E_X)/(E_X - E_{BH^+}),$$

where E_B is the extinction coefficient of the unionized indicator, E_{BH^+} is the extinction coefficient of the completely ionized indicator and E_X is the extinction coefficient of the solution under consideration. By substituting this ratio into equation (1) calculations of the pK_a of the indicator, using the known acidity functions for the sulfuric acid solutions, and the acidity functions of trichloroacetic acid, using the known pK_a of each indicator, were readily made.

Results and Discussion

Data used for the calculation of the pK_a and the calculated pK_a for 2-chloro-4-nitroaniline are given in Table I.

TABLE I

Extinction coefficients and pK_a for 2-chloro-4-nitroaniline ($E \times 10^{-3}$).

H_2SO_4,%	H_o	365	370	375	377.5	380	Av. pK_a
Water		11.9	12.2	12.3	12.2	11.9	
4.76	+0.25	11.0	11.4	11.5	11.4	11.2	—0.88
9.62	—0.15	9.8	10.0	10.1	10.1	10.0	—0.85
14.72	—0.61	8.0	8.2	8.3	8.3	8.2	—0.93
19.65	—0.87	5.9	6.1	6.2	6.2	6.1	—0.89
28.93	—1.53	2.2	2.3	2.3	2.3	2.2	—0.86
49.55		0.2	0.2	0.2	0.2	0.2	
						Average	—0.88

Using the extinction coefficients for solutions of the three nitrogen indicators in several concentrations of trichloroacetic acid, the acidity functions of trichloroacetic acid solutions were calculated in the same manner indicated above. The resulting acidity functions are listed in Table II. Results obtained recently by Randles and Tedder (9), using a colorimetric method, are given for comparison. In order to obtain figures at the same concentrations used in the present study their data were plotted and the acidity function read from the plot at each desired concentration.

The pK_a of 2,4,6-trimethoxybenzaldehyde was found to be —2.08. No spectroscopic evidence for the ionization of this indicator was observed at any concentration of trichloroacetic acid, including melted pure trichloroacetic acid. Hence, no data for this indicator are given. From the above observation it is unlikely that the acidity function of pure trichloroacetic acid exceeds —1.25.

The present results for the acidity function of trichloroacetic acid are consistent with those of Randles and Tedder within the usually-acceptable experimental error (±0.05 at lower concentrations and ±0.10 at higher concentrations). Both recent studies indicate trichloroacetic acid to be a stronger acid than was indicated by Hammett's results. On the other hand, trichloroacetic acid in the higher concentrations is a weaker acid than the strong mineral acids.

TABLE II

Acidity function of trichloroacetic acid.

	H_0				
	p-nitroaniline		o-nitroaniline		2-chloro-4-nitro-aniline
Molar conc.	Present study	Randles Tedder	Present study	Randles Tedder	
0.197	+0.80	+0.83			
0.394	+0.51	+0.54	+0.48	+0.52	
0.788	+0.32	+0.25			
0.98	+0.12	+0.14	+0.14	+0.14	
1.18	+0.03	+0.05			
1.48					+0.16
1.58	—0.03	+0.03			
3.16	—0.03	+0.03			
4.74			+0.04	+0.03	
4.82	—0.12	—0.05			
6.4			+0.02	+0.01	
7.2				—0.40	—0.51
7.9				—0.78	
8.6					—0.95 to —1.05

The authors have determined the pK_a of 2-chloro-4-nitroaniline for the first time and have measured the acidity function of trichloroacetic acid at a higher concentration than has previously been reported.

Randles and Tedder suggest a reasonable explanation for the low acidity function for trichloroacetic acid. The more concentrated solutions have a low dielectric constant. Since solvents of low dielectric constant increase the difficulty of forming charged ions, ionization does not occur as readily in concentrated solutions of trichloroacetic acid as one would otherwise expect.

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Determination of Esters of Acetylenic Alcohols

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Various physical and chemical methods may be applied to the determination of acetylenic compounds, depending on the nature of the acetylenic group and on the presence of other functional groups in the molecule. The most general methods for acetylenic compounds are based on Raman and infra-red absorption spectra measurements (1), but these are not the most suitable for the type of compound under consideration. An ester of an acetylenic alcohol could be determined by reaction at either the acetylenic or the ester group, but the most specific method would be one in which both groups are involved. Actually, the acetylenic alcohols are quite volatile and can usually be steam-distilled. Thus the most useful procedure when dealing with esters of acetylenic alcohols is a preliminary hydrolysis and steam-distillation of the acetylenic alcohol. Then the acetylenic alcohol may be determined by any of the usual acetylene methods. If the acetylenic function is a terminal one, then an acetylide method is especially appropriate. In fact, the presence of an acetylide-forming reagent in the receiver during the steam distillation provides a means of trapping the otherwise volatile acetylenic compound.

The mono-esters of dicarboxylic acids with 3-methyl-1-pentynol-3 are ideally suited to the procedure just mentioned. The phthalate and succinate mono-esters have been studied and a method for their assay in pharmaceutical preparations was developed. The hydrolysis and steam-distillation of the acetylenic alcohol are accomplished simultaneously in a modified Pregl micro-Kjeldahl distillation apparatus. The steam is supplied from a steam generator having an internal electric heating coil, and the apparatus is flushed out at the conclusion of each determination by sucking back the reaction mixture and rinse water into a trap. The 3-methyl-1-pentynol-3 in the distillate is trapped in an alcoholic silver nitrate solution, which is then titrated with sodium hydroxide according to Method B of Siggia (2).

Interfering substances in this method are volatile alkaline compounds such as amines, for which correction could be easily made by a blank determination without silver nitrate. The problem of volatile alkaline materials has not been encountered, however, in the pharmaceutical preparations which have been studied. A problem which may be encountered in assays of the amounts of mono-ester present in various compositions is the interference of neutral acetylenic substances. The di-ester as well as the free alcohol may be present; a relatively simple extraction method has been devised for the determination of the amounts of each of these for correction of the total acetylene results. Appreciable amounts of neutral acetylenic substances were found in the case of the mono-succinate, but not in the case of the mono-phthalate.

Apparatus

The principle item necessary for carrying out the described method is a specially modified Pregl type micro-Kjeldahl distillation apparatus. The fundamental principles involved in the modified apparatus are the same as in the Kjeldahl determination, so that the apparatus listed for this determination in catalogs (3) may be referred to for guidance. The unmodified apparatus could be used successfully, no doubt, but the apparatus which was actually used is more suitable for this particular determination. The points of difference will be listed:

1. The distillation flask is operated in a vertical position and the condenser is attached securely to it, also being in a vertical position.
2. The Kjeldahl-type trap is replaced by a plain bulb having a small outlet at the top leading directly to the condenser (one piece of glass). No joints or rubber tubing intervene in the path of the distillate.
3. The sample addition tube is about 1 cm. ID and is vertically aligned. The steam enters through a side-arm about 2 cm. below the opening, which is closed by a rubber stopper during the distillation. At about 3 cm. below the steam inlet there are several indentations which serve to hold up capsules while disintegration is taking place.

Experimental Procedure

A sample of the material to be assayed is ground up and mixed if necessary, and a portion containing about 0.3 to 0.4 Gm. of mono-ester is weighed out into a small beaker. The distillation apparatus is preheated by passing in steam for 5 to 10 minutes and then sucking back. The rubber stopper is removed from the addition tube so that the sample and reagents may be introduced. First, three drops of anti-foam (octanol or silicone) are put in, then the sample, with the aid of a funnel and a nichrome wire. Then the beaker, funnel, and wire are rinsed with ethanol (2 or 3 ml.). Finally, the funnel is removed and sodium hydroxide is added (ca. 5 ml. of 2 N solution). The steam trap drain being open, the stopper is replaced and the heat for the steam generator is turned up high. The receiver, a 125 ml. erlenmeyer flask containing 20 ml. of alcohol (# 30) and 15 ml. of silver nitrate solution (100 grams per liter), is put in place with the delivery tube barely submerged. When the steam trap is hot, the drain is closed and steam is passed at 80 volts to heat up the entry tube. (Note: The voltages are given for guidance, but only apply exactly to the particular apparatus used.) When the entry tube is hot, the voltage is reduced to 70 and the reaction mixture is heated up. By pinching the rubber tubing at the steam inlet a few times, the entry tube may be washed out by the reaction mixture. Then the voltage is reduced to 67 when the reaction mixture is hot and the ethanol begins to come over. The timing for the 30-minute distillation is begun at this point. After the ethanol has distilled over, the voltage must be gradually reduced to 63 to control foaming. For a few minutes the foaming must be carefully watched and the steam trap drain opened if necessary. When the foaming diminishes, the voltage is gradually raised to 67 and left there for the remainder of the 30-minute distillation. For the last five minutes, the delivery tube is raised out of the liquid in the receiver and rinsed off on the outside. When the distillation time is completed, the current is shut off and the apparatus cleaned out by sucking back deionized water. The mixture in the receiver is then titrated with standard sodium hydroxide (ca. 0.1 N) using a mixed indicator (Note 2). The end-point is taken as the place where there is no longer a pinkish tinge to the cloudy solution; the color is a bluish gray. The concentration value of the sodium hydroxide which is used in calculation of the results is that determined with the same indicator. The stoichiometry is one equivalent of sodium hydroxide per mole of mono-ester.

Notes on the Procedure

1. The anti-foam agents are needed only when certain excipients are present. Raw material is sufficiently pure that foaming is not serious.
2. The mixed indicator is a solution of methyl red (0.1%) and methylene blue (0.05%) in alcohol. Six drops are used.
3. The pH at the equivalence point is 3.5; the color change apparently corresponds to this point, the indicator being affected by the presence of the silver ion.

For determination of the neutral acetylenic substances, a sample containing one gram of mono-ester is dissolved in 25 ml. of ethyl acetate, unless there is insoluble material, in which case 40% more is dissolved in 35 ml. and allowed to settle so that 25 ml. of clear supernatant solution may be used. The ethyl acetate solution is extracted successively with sodium bicarbonate (25 ml. of 5% solution), sodium carbonate (5 ml. of 5% solution), and water (three times of 5 ml. each). The free acetylenic alcohol is extracted out with silver nitrate (10 ml. and 5 ml. of 100 grams per liter solution) and collected in a 125 ml. erlenmeyer flask. After two washes of 10 ml. water each, these being combined with the silver nitrate extracts, the whole is titrated with sodium hydroxide as in the fundamental procedure of the first paragraph. It has been found that a recovery of about 90% is obtained in the case of 3-methyl-1-pentynol-3.

The ethyl acetate solution remaining after the extraction of the acetylenic alcohol is evaporated to dryness by an air jet. The non-volatile di-ester remaining is titrated in the usual manner after addition of 15 ml. of alcohol (#30) followed by 10 ml. of the silver nitrate solution.

Results

Some typical results for the two parts of the procedure are shown in Tables I and II.

TABLE I

Fundamental procedure:— Mono-ester plus di-ester and free alcohol.

3-methyl-1-pentyn-3-yl acid phthalate			3-methyl-1-pentyn-3-yl acid succinate		
Raw material (pure)	100.5%	0.0	Individual capsules No. 7140 (½ Gm.)	97.8%	—0.3
	100.5	0.0		97.8	+0.4
	100.1	—0.4		97.2	—0.2
	101.1	+0.6		97.4	0.0
	Av. 100.5%	S.D. ± 0.4		Av. 97.4%	S.D. ± 0.3
Tablets No. 206854B (84.2%)	84.1	—0.4			
	85.0	+0.5			
	84.0	—0.5			
	84.8	+0.3			
	Av. 84.5%	S.D. ± 0.5			

TABLE II

Neutral acetylene procedure:— Di-ester and free alcohol only.
Mole percent.

3-methyl-1-pentyn-3-yl acid phthalate		
	Free Alcohol	Di-ester
Tablets No. 206854B	0.3	0.3

3-methyl-1-pentyn-3-yl acid succinate				
Amount H_2O	Temperature	Months	Free Alcohol	Di-ester
0.9%	25°C	0	4.8	—
		4½	5.3	0.3
4.7%	25°C	4	7.7	1.8
	37°C	4	9.7	7.8

The results show a degree of precision and accuracy which is quite good for a pharmaceutical control method. In addition, the procedure has been found to be quite practicable in the routine assay of the 3-methyl-1-pentyn-3-yl acid phthalate which is the active ingredient in a veterinary anthelmintic tablet currently being marketed. Though only a rather special class of esters of acetylenic alcohols has been studied, it is anticipated that the procedure could be extended to many other classes of this type of compound by the introduction of some simple modifications.

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Coordination Studies: Dipyridylamine and 3,3′-iminobispropylamine

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Introduction

The research reported is part of a continuing study of the coordination of amines with copper (II) and nickel (II) ions, with particular emphasis on the nature of the ions, their stability in solution, and the effect of structural features on stability.

The formula of dipyridylamine (pyridine, 2,2′ iminodi-), first prepared in 1914 by Chichibabin and Zeide (3), suggests several possible centers of coordination. Coordination through the nitrogen atoms of the two pyridine rings would produce a six-membered ring structure. If the secondary amine position were also involved, two four-membered rings could be present, but the steric factors make this unlikely. Coordination at one position only is also possible.

To compare the effect of ring size, 3,3′-iminobispropylamine (3,3′-diaminodipropylamine) was chosen, since diethylenetriamine (2,2′-diaminodiethylamine) has been investigated previously (6). The coordination of this compound has been examined recently by Hares, Fernelius, and Douglas (4). Our work in progress at the same time has attacked the problem by different methods.

Theoretical

Spectrophotometric measurements may be used to establish that coordination takes place, to establish conformity to Beer's Law, and to obtain the formula of the ions present by the method of continuous variation of Job (5) and the spectrophotometric titration method of Yoe and Jones (7).

Application of the pH titration method developed so extensively after introduction by Bjerrum (4) often provides an excellent method for the study of coordination of this type. However, insolubility of the complex ion is often a limiting factor. Mixed solvents, especially water-dioxane introduced by Calvin and Wilson (2), have been used to increase the solubility of the ions. Determination of the acid dissociation constants for the protonated amines under comparable conditions of ionic strength is necessary as preliminary. With this information, measurement of the pH of solutions containing known concentrations of metal ion, acid, and coordinating agent gives data for calculation of the equilibrium constant.

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[1] The senior author wishes to thank the Research Corporation for a Frederick Gardner Cottrell grant.

Experimental

The dipyridylamine was purchased from the Reilly Tar and Chemical Co. and the 3,3′-iminobispropylamine from the Mathiesen Company.

The dipyridylamine was recrystallized from hot water. The white needles were dissolved in purified dioxane and the solution standardized by potentriometric titration in approximately 50% water-dioxane mixture.

Dioxane was purified by refluxing for 8 hours with 10% by weight of 1 N HCl, drying over NaOH, and distillation over sodium.

The 3,3′-iminobispropylamine was purified by distillation at 20 mm. Hg pressure. Solutions were standardized by titration with nitric acid using methyl orange as indicator.

Standard solutions of cupric nitrate, nickel nitrate and nitric acid were prepared from reagent grade chemicals and standardized by the usual procedures.

The spectrophotometric titration was performed by preparation of solutions of constant concentration of metal ion and multiples of this value for the amine concentration. The optical density was measured at the wave length of maximum absorption.

For the continuous variation measurements, a series of solutions at constant total concentration was prepared, with the concentrations varied from 0.01 molar in metal ion to 0.01 molar in amine. The optical density of the solutions was measured at the wave length of maximum absorption.

Spectrophotometric measurements were made with a Beckman model DU instrument.

The acid dissociation constants of 3,3′-iminobispropylamine (3,3′-diaminodipropylamine) were determined from pH measurements of a series of solutions containing 0.1 M barium chloride, 1.0 M potassium nitrate, 0.094 M nitric acid and amine concentration in the ranges 0.034 to 0.043 M, 0.056 to 0.076 M, and 0.105 to 0.155 M. The pH measurements were made at 30° C. ± 0.2° C. with a Beckman model G pH meter standardized against Beckman buffer solutions.

Discussion of Results

3,3′-iminobispropylamine

The acid dissociation constants of 3,3′-iminobispropylamine were found to have pK values of 8.15, 9.75, and 10.75 at 30° C. These values are almost the same as those determined by Hares, Fernelius and Douglas: 8.02, 9.70, 10.70. The present values were determined at a higher ionic strength and are reported since conditions were not identical.

The wave length of maximum absorption of the copper (II) complex ion was found to be 590 mμ. At this wave length the amine may be used as a colorimetric reagent for copper. Both the spectrophotometric titration and continuous variation methods indicate that two moles of amine per mole of copper are present in the ion. Evidence for a 1:1 ratio of copper and the amine is obtained in the titration, but the 2:1 ratio seems more stable. This does not agree with Hares, Fernelius and Douglas who report a formation constant only for the 1:1 ratio.

With nickel (II) ions a maximum absorption is found at 570 mμ. Spectrophotometric data indicate both a 1:1 and 2:1 ratio of amine to nickel ions.

2,2′-dipyridylamine

The absorption curve of 2,2′-dipyridylamine with copper (II) ions shows peaks at 420 mμ and 660 mμ. The absorption at 420 mμ is obscured in the presence of amine, so the longer wave length was used in this investigation. The color of this ion in water-dioxane solution is green. Continuous variation data at 660 mμ give a coordination number of two for this ion.

The color of the ion of nickel and dipyridylamine is not intense, but does show maximum absorption at 560 mμ and at 900 mμ. Spectrophotometric data gave evidence of a coordination number of two for the ion formed with nickel. For this ion a 50% mixture of ethanol and water can be used as the solvent.

Further research of the coordination of this amine with copper is proceeding.

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Aluminum Solutions instead of Ferric in Qualitative Testing for Acetate

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Introduction

A common test for acetate is the precipitation of basic ferric acetate in a boiling solution. A serious objection to this method is the necessity for a definite very faint acidity of the generally used ferric chloride solution. Ferric chloride solution, made from most preparations of ferric chloride, is usually too acid to give any precipitate with acetate. The reduction of this acidity with ammonium or sodium hydroxide must be just sufficient so that the solution will not hydrolyze upon boiling with precipitation of a basic salt. This "blank" is the critical part of the test. Students usually have trouble getting the ferric chloride of just the right degree of acidity. Ammonium ferric alum gives a solution that hydrolyzes and precipitates when water is added, hence it has no advantage over ferric chloride as, in its use acid must be added before using. These iron solutions cannot be made neutral to litmus because hydrolysis constantly supplies acid. The acetate solution being tested must be neutral, but this can be easily done with litmus as there is no troublesome hydrolysis.

With the properly prepared ferric chloride solution, the acetate test gives very satisfactory results with students in the qualitative laboratory. However, if the ferric solution is too acid the test is negative with or without acetate and if too low acidity it is positive all the time.

Review

The most complete research on this method was done by Curtman and Harris (1). They found that a blank must be run each time to make sure no precipitate would form in the absence of acetate. On the other hand, no precaution was suggested for avoiding the error due to too much acidity. The greater the acidity of the ferric solution the less is the sensitiveness of the test. A summary of their results are shown in this table:

Mg. Fe per cc used	50 cc final solution mg. acetate		200 cc final solution mg. acetate	
	not giving test	giving test	not giving test	giving test
5	15	20	25	50
10	30	40	40	60
25	50	70	75	

Contribution No. 758 from the Chemical Laboratories of Indiana University.

These data show that the sensitiveness is reduced by increasing the volume of the solution and by increasing in the quantity of ferric chloride added. No explanation is apparent for increased dilution reducing the sensitiveness. The poorer results with greater quantities of the ferric solution could have resulted from the greater total acid present in the larger volume of the "unneutralized" ferric chloride. Their conclusion is that the test is not sensitive enough for good qualitative analysis. Their low sensitiveness could have been due to too high an acidity of their iron solution.

Experimental

Certain possible advantages of aluminum—using the potassium alum instead of the ferric chloride—are apparent. This salt contains no free acid. Its solution does not require any neutralization and its solution does not give a precipitate when a "blank" is boiled. This makes possible an easily prepared uniform testing solution without any of the troublesome and uncertain manipulation of "blanks."

Results with alum are as follows:

Mg. of alum used	Mg. of Na acetate no test	Mg. of Na acetate giving test	Volume of final solution
10	5	10	50
25	5	10	50
10	—	2.5	100
25	2.5	5	100

Conclusion

These data show that aluminum is much more sensitive than the ferric—as much as 25 times in some of the cases. It is possible that if Curtman and Harris had more fully neutralized their ferric, the test would have been more sensitive and their conclusion would not have been that "the ferric test for acetate is not sensitive enough." Also, the results in this research shows that the test is more sensitive the greater the dilution which is contrary to the ferric results. Also, an increase in the quantity of alum used did not greatly affect the sensitiveness of the test while the ferric test was less good.

One less desirable feature of the test with aluminum is that the basic aluminum acetate is white and, when the quantity of precipitate is small, it is much more difficult to see than is the highly colored basic ferric acetate.

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ENTOMOLOGY

Chairman: Donald J. Schuder, Purdue University

Howard O. Deay, Purdue University, was elected chairman for 1957

ABSTRACT

Test of Some New Insecticides for Control of Red Clover Insects. Ray T. Everly, Purdue University.—Five insecticides which had not been tested previously for control of the Meadow spittlebug, *Philaenus leucophthalmus* (L.), in Indiana, were applied as emulsions to red clover plots with a low-gallonage, low-pressure small plot sprayer. The insecticides tested included Guthion, Dipterex, Chlorthion, X7744 (an aryl urethane), X8305 (a substituted thianophosphate), and lindane. Lindane gave excellent control with Guthion almost equally effective. X8305 also showed promise. This is the first indication that an organic phosphate insecticide would control the spittlebug. The other insecticides were ineffective. Guthion also showed the best control of the lesser clover leaf weevils, *Hypera nigrirostris* (F.) and *H. meles* (F.), as measured by the numbers of damaged buds per 100 stems. X7744 also indicated some value against these insects. Better timing and slightly higher dosages were indicated.

A Specific Virus Disease for Control of the European Pine Sawfly, *Neodiprion sertifer* (Geoff.)[1]

Donald L. Schuder, Purdue University

A specific virus disease for the biological control of the European pine sawfly, *Neodiprion sertifer* (Geoff.), has been introduced into Indiana. This polyhedral virus disease affecting the European pine sawfly was originally obtained from diseased sawfly larvae in Sweden and cultured by the Canadian Laboratory of Insect Pathology, Saulte Ste. Marie, Ontario. The Forest Service of the United States Department of Agriculture subsequently obtained some of the virus material and the writer working with the latter department first experimented with the virus disease at Bristol, Indiana, in 1953.

The European pine sawfly *Neodiprion sertifer* (Geoff.) is probably the most severe pest of pine trees in Indiana. It is a foreign pest which was accidentally introduced into New Jersey about 1925. The sawfly has gradually spread westward and reached Indiana about 1950. This sawfly occurs in the northern half of the state and the infestation is particularly heavy near the Michigan state line in the vicinities of LaPorte, Elkhart and Bristol, Indiana.

The larval or "worm" stage attacks practically every species of pine grown in the state, but is most injurious to red and Scotch pines, the two pine species most popular for reforestation and Christmas tree production. The sawfly larvae feed from late April until mid-June and heavy populations strip the trees of all of their old needles. When the new growth candle breaks and the new needles are produced, after the larvae have pupated, the individual branches have a tufted or "mule-tailed" appearance. The thin, sparsely leafed trees are worthless for Christmas trees or windbreaks and if defoliation is repeated for two or three years, tree mortality follows.

Because of the seriousness of the sawfly infestation, various methods of controlling the insect were tried including the application of DDT insecticides. DDT was very effective against the sawfly, but had to be applied each year. (The use of DDT on other crops had caused a mite problem following its use.)

No virus disease had been found in American infestations of the European pine sawfly (2).

Since 1953 the polyhedral virus has been applied to over 600 acres of sawfly infested pine plantings in Elkhart, Steuben and LaPorte counties and appears to be the answer for controlling this sawfly in pine plantings. The advantages of the virus disease over the application of DDT to pines are: 1)—The virus disease does not need to be applied every year. When applied properly, mortality is about 89 percent. This

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[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1050.

allows sufficient survival so that the disease is carried over from one season to the next indigenous in the sawfly population. Epizootics keep the population so low that no economic damage occurs. The virus is transmitted from one generation to the next via the eggs of the diseased females. Little or no virus persists on the foliage. (4) 2)—The virus disease does not affect other pest populations and is harmless to man and other animals. 3)—Once the disease is established in an area, the grower can prepare his own inoculum. To obtain an adequate amount of inoculum usually 1000 diseased larvae are collected. These are macerated and placed in a liter of chlorine free water to rot until the following spring. The diluted aqueous suspensions of the body fluid of virus killed sawflies thus serve as inoculum to infest new areas with the disease (6). The virus suspension can be applied by airplane mist blower or compressed air sprayer (2). The stock solution made from diseased larvae is diluted so that one milliliter, containing one million polyhedra, is applied per acre. It is applied as a fine mist; for example, one gallon of diluted material is applied to one acre by airplane. It is not necessary to drench the trees for this actually wastes material. Two pounds of powdered milk is sometimes added to each 40 gallons of suspension for airplane application. This material serves to stick the virus particles on the foliage and, by increasing the density of the sprays, increases penetration of the spray into dense foliage (5).

The virus should be applied either early in the morning or late in the evening when there is no wind. The ideal time for application is between May 1st and May 14th. This early application, when the sawfly larvae are small, prevents serious defoliation. Mortality from the virus disease becomes evident in about ten days after the spray is applied (3). The diseased sawfly larvae turn black and may be seen hanging head downward from the foliage. The body contents become liquified so that the dead larvae become essentially a sack of virus particles suspended in the body fluids. In about another week, the dead larvae dry up into black mummies.

As a result of introducing the virus in Indiana, the immediate threat to Indiana pine plantings from the European pine sawfly has been reduced. Adequate control is maintained for several years by recurring virus epizootics once the disease is established.

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Strawberry Virus and Insect Vectors

G. Edw. Marshall, Purdue University

The only known vectors of strawberry virus are aphids of the genus *Capitophorus.* In southern Indiana an indigenous species, *C. minor* Forbes, which feeds on the fruits, has been identified. Other suspected carriers are *Aphis forbesi* Weed and two or three species of spider mites which have been identified from strawberries.

Although many states have made recommendations for measures to prevent the spread of virus infection, the effectiveness of such measures may be questioned on the grounds that aphids are found in strawberries throughout the season from early spring before plants push through the mulch to late fall. Under these conditions, the only certain method to stop the spread is a demeton spray program where the insecticide is applied frequently enough to prevent the development of aphids at any time during the growing season.

The method most commonly used to determine the presence of the virus in strawberries is to graft a stolon of the suspected variety on that of *Fragaria vesca,* a wild species. If the virus is present, the foliage of *F. vesca* will become mottled. Using this method, research workers have concluded that most common stock is infected. Stolon grafting is not practical for the grower, as it indicates the presence or absence of the disease in only one plant at a time. It would be useful, however, as a method to indicate the presence of the virus in the old patch and the need to replant with virus-free plants.

Observations to date have not answered the question as to the length of time patches set with virus-free plants will remain free of the disease. Robinson and Dunlap varieties set three years ago in our plots are still vigorous in both growth and fruit production. Additional information on rapidity of spread under different insect population levels is needed.

A comparison in 1955 of the number of new plants produced per mother plant of four varieties showed an average increase of two for the virus-free stock. The average number of new plants from virus-free stock as against common stock was as follows: Aroma, 7.51 and 5.67; Dunlap 10.22 and 7.88; Premier 7.62 and 7.32; and Robinson 8.92 and 5.55. These figures were recorded between April 12 and July 10 at which time the stolons were thick enough on some varieties to require thinning.

Purdue University, Agricultural Experiment Station, Journal Paper No. 1047.

Insects of Indiana in 1956

J. J. Davis, Purdue University

As in 1955, major insect problems were fewer and of less importance than in normal years. In general, rainfall was ample until into September and thereafter conditions were unusually dry. Also temperatures throughout the year were below normal.

Field Crop Insects

Cutworms. The glassy cutworm *(Crymodes devastator)* was more serious than for many years. Greatest damage was to corn in light sandy soils. Many thousands of acres of corn were destroyed in Starke, LaPorte, and other northern Indiana counties. The black or overflow cutworm *(Agrotis ypsilon)* was widespread throughout the State, especially in muck areas, but not as serious as a few years back.

European corn borer *(Pyrausta nubilalis)* overwintered in larger numbers than for several years, especially in the central and northern part of the state. The first generation larvae were very abundant in the early part of the growing season, but the population of borers dropped off rapidly so that the resulting number of adults were considerably smaller than was anticipated. Total damage by the corn borer in the state was light with a few scattered areas of moderately severe damage to early planted corn. Fall survey showed a low overwintering population.

The corn earworm *(Heliothis zea)* was generally more abundant than in 1955 with heavy infestations in the southern part of the state.

Alfalfa plant bug *(Adelphocoris lineoliatus)* was more abundant this year than usual.

Grasshoppers (principally *Melanoplus mexicanus* and *M. femur-rubrum*) were not seriously destructive to cultivated crops, due in part to the succulence of native vegetation, the natural habitat of the insects.

Chinch bugs *(Blissus leucopterous)* did not materialize as a serious problem, although they did winter over in moderate and threatening numbers.

The spittle bug *(Philaenus leucopthalmus)* infestations continued moderately heavy. Although this interesting insect is a common native species on weeds, it was 10 years ago (1946) that it rather suddenly appeared as a pest of several cultivated crops. Since then it has been a rather regular annual pest, especially on clover, alfalfa and other legume crops, strawberries and flowering plants. Aside from actual damage to the crops, the infestations have made it difficult to cure hay since the spittle masses dry slowly and keep the forage damp after it is cut. Effective control measures have been developed and increasing numbers of farmers are applying controls when necessary. In 1956 there was virtually no spraying for spittle bug because of the low early populations and the fact that most farmers had more hay and pasture than needed.

The armyworm *(Pseudalelia unipuncta)* was not destructively abundant in Indiana this year.

Northern corn root worm *(Diabrotica longicornis)* adults were common throughout the state. They were unusually abundant and destructive to corn silks in the Vincennes area, resulting in incompletely fertile ears.

Clover leaf weevil *(Hypera punctata)* was scarce during the spring months.

The spotted alfalfa aphid (*Pterocallidium* sp.) was reported for the first time in Indiana this year by M. Curtis Wilson. It is believed this species first came into Posey County the latter part of August. By October 15 it had spread along the Wabash and Ohio rivers into seven Indiana counties, as follows: Gibson, Knox, Perry, Posey, Spencer, Vanderburgh, and Warrick.

The Hessian fly *(Phytophaga destructor)* did not materialize as a pest as anticipated.

Vegetable Garden Insects

Tomato hornworms (*Protoparce* spp.) were scarce on tomatoes and not as abundant as normally on tobacco along the Ohio River. They were late in appearing.

Squash bugs *(Anasa tristis)* which have been abundant and destructive to commercial plantings the past few years, especially in southern Indiana, were rather scarce.

Bean leaf beetle *(Cerotoma trifurcata)* was a common pest of garden beans and soybeans. This insect has been building up on soybeans for several years and in 1956 it was severe enough in some localities (Crawfordsville) to justify treatment with DDT.

Cabbage maggot *(Hylemya brassicae)* was less abundant than normal.

Tomato fruitworm *(Heliothis zea)* was especially abundant on green and ripening tomatoes during the month of September. In many fields the infestation was 15 to 20 percent, and canning plants throughout the state rejected many loads of worm infested fruit.

Tree Insects

Bagworms *(Thyridopteryx ephemeraeformis)* continue to be the major pest of ornamental plantings and shade trees, and were so abundant as to be considered the most severe year on record in Indiana. New infestations were reported in Starke and St. Joseph counties. The period of egg hatching was prolonged.

Elm leaf beetle *(Galerucella xanthomelaena)* infestations have been especially severe on Chinese elms, most inquiries coming from central and southern Indiana. Also they have been a continuing household pest.

Zimmerman pine moth *(Dioryctria zimmermani)* was found for the first time in Indiana in LaPorte county by D. L. Schuder. This is a new record for the state. The insect was found infesting red and scotch pines.

Bronze birch borer *(Agrilus anxius)* was a serious pest to birches where new trees were planted and where drought conditions over the last two years was serious.

Maple bladder gall *(Vasates quadripes)* was common throughout the state.

The giant aphid *(Longistigma longistigma)*, our largest species of aphid, was reported from several timber trees, including oak and linden. Apparently it is of no economic significance.

Melanoxantherium smithiae was generally common on willow. Although of no apparent damage to the host, the species migrates about in the fall and where crushed, on lawn seats and the like, leaves a blood red stain.

Juniper webworm *(Dichomeris marginella)* was reported as heavily infesting junipers in a number of localities, mostly from Central Indiana.

Mimosa webworm *(Homadaula albizziae)* was reported as heavily infesting honey locust in the Indianapolis area.

European pine sawfly *(Neodiprion sertifer)* has been normally abundant on red and scotch pine plantings in northern Indiana. D. L. Schuder reports excellent results from the artificial use of the virus disease which he introduced into Indiana several years ago.

Red-headed pine sawfly *(Neodiprion lecontei)* has been destructively abundant on pine in southern Indiana.

The yellow-necked *(Datana ministra)* and red-humped *(Schizura concinna)* caterpillars were abundant on various trees, especially those of the apple family.

Household and Miscellaneous Pests

Roaches continue as the major household pest. Although several species are involved, the Oriental roach *(Blatta orientalis)* is the major problem.

The clover or grass mite *(Bryobia praetiosa)* continues as a major annoyance in homes in the spring and fall of the year. As observed in the past, the infestations develop in new lawns as a rule.

Box-elder bugs *(Leptocoris trivittatus)* and elm leaf beetles *(Galerucella xanthomelaena)* have become more or less annual pests in many parts of the state, entering homes in the fall, while seeking places of hibernation. Although they do no damage to household furnishings, their presence is annoying. The box-elder bugs breed on the common box-elder and the elm leaf beetles primarily on Chinese elms. Although both trees are not desirable shade trees, we do not advocate cutting down such trees in the immediate vicinity of homes because the bugs and beetles may migrate from other trees several blocks away. The gradual replacement of these trees by species better suited for shade trees may be desirable.

The usual number of complaints have been received regarding honeybee swarms taking up quarters in walls of homes.

Ants of various species were the subject of many complaints, perhaps the majority coming in the fall of the year and mistaken for termites. However, many inquiries have referred to ants in the home and as reported a year ago, especially in slab-constructed homes.

Aphids on trees, especially elm trees, have been commonly annoying because of the "honey dew" produced. This tree sap passing through the digestive tract is annoying in two ways, first by spotting cars parked under the trees and second by providing a medium for the development of black sooty fungus on leaves of flowering plants growing under and nearby the trees.

Carpet beetles, especially the black carpet beetle *(Attagenus piceus)* was reported repeatedly from all parts of the state. But few reports of the clothes moth were received.

Click beetles (*Melanotus* spp.) were again reported abundant and annoying in homes. The first report of click beetles in homes which our observations record was in 1954 and reported to this Academy.

Many reports of damage by powder post beetles (*Lyctus* spp.) were received during the year. In many cases they were mistaken for termites.

During the year to date, 115 letters were received regarding the control of termites *(Reticulitermes flavipes).* These pests are the number one building problem. Reports of damage to underground cable were received from the northwestern part of the state. Dr. T. E. Snyder, world authority, verified the cause of damage.

In 1954 we reported infestations of the damp wood or rotten wood termite *(Zootermopsis angusticollis)* in shipments of Douglas fir lumber to South Bend from Oregon. Again this year, September 6, an infestation was reported in Douglas fir in a shipment of lumber from Tillonosh, Oregon, to a lumber company in Anderson, Indiana.

Several species of millipedes have been reported to be abundant in lawns around homes during the dry weather, such infestations usually occurring adjacent to wooded areas.

The rose chafer *(Macrodactylus subspinosus)* damaged flower garden plants in several localities of northern Indiana.

The saddle back caterpillar *(Sibine stimulea)* was more abundant than usual during September, especially on corn.

The Japanese beetle *(Popillia japonica)* has become more abundant and widespread in distribution during 1956. In the area around Kentland the adult beetles were unusually numerous and destructive on soybeans.

The Sex of European Corn Borer Moths Taken at Light Traps[1]

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One of the factors entering into the use of light traps as a possible insect control measure is the sex of the insects captured. The present paper deals with the sex of European corn borer moths taken in different years and at different locations, by lamps emitting different wavelengths and intensities of radiant energy, by traps placed at different heights, and by traps placed in different directions in regard to the wind.

Studies on Year of Capture, Generation, and Location: One unidirectional light trap, equipped with a 15-watt BL lamp, was operated in Lawrence and another in Tippecanoe county, Indiana from 1953 through 1956. The traps were operated during the entire period of flight of both generations so that the proportion of the sexes caught was not influenced by the time of emergence of the moths. As a rule males are predominant at the beginning of the flight period and females toward the end.

TABLE 1

Sex of corn borer moths caught at light traps in Lawrence and Tippecanoe counties, Indiana. 1953-56.

Year	Lawrence County				Tippecanoe County			
	15-w BL				15-w BL			
	June–Flight		Aug.–Flight		June–Flight		Aug.–Flight	
	No. Moths	Per Cent Fem.	No. Moths	Per Cent Fem.	No. Moths	Per Cent Fem.	No. Moths	Per Cent Fem.
1953	—	—	29	69	—	—	50	54
1954	400	67	106	42	86	47	89	45
1955	218	47	116	31	186	65	646	40
1956	256	45	42	52	546	43	249	46
Totals								
1953-56	874	55.5	293	45.1	818	48.3	1034	42.3

As shown in Table 1 the per cent of the moths of the June flight which were female varied in Lawrence county from 45 to 67 during the three years and that of the August flight from 31 to 69. In the same years, in Tippecanoe county the percentage of females captured varied from 43 to 65 in the June flight and from 40 to 54 in the August one.

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[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1044.

In Lawrence county about 10 per cent more of the moths of the June flight were females than of the August flight while in Tippecanoe county about six per cent more of the June than the August ones were females. On an average there was a higher percentage of female moths of the June flight in Lawrence than in Tippecanoe county. The percentage of females in the August flight was about the same for the two counties.

Studies on Wavelengths. The results of an experiment conducted in August, 1956, in which six traps equipped with different lamps were compared, are given in Table 2.

TABLE 2

Sex of August-flight, corn borer moths taken at lamps emitting different wavelengths of radiant energy. Tippecanoe county, Indiana, 1956.

Lamp	No. Moths	Per Cent Female
15-w BLB	463	63
15-w BL	481	68
15-w Green & 15-w BL	731	62
Green Fluorescent	511	54
150-w Incandescent	526	57
15-w Pink Fluorescent	302	57

The lamps were rotated every night for 18 nights. The BL lamp emits about 90 per cent of its energy at 3650 A (near ultraviolet) and the rest in the visible spectrum. The BLB lamp has a filter which cuts out most of the visible light. As shown in the table the lamps emitting most of their energy in the ultraviolet region of the spectrum attracted a higher percentage of females than did those emitting longer wavelengths.

Studies on Intensities. In 1949 an experiment was conducted in which three intensities of mercury-vapor lamps during the June flight and a 15-watt BL and two intensities of mercury-vapor lamps during the August flight were compared.

TABLE 3

Sex of corn borer moths taken at traps equipped with lamps of different intensities. Tippecanoe County, Indiana. 1949.

Lamps	June–Flight No. Moths	Per Cent Fem.	Lamps	August–Flight No. Moths	Per Cent Fem.
250-w M-V	567	70.4	15-w BL	52	65.4
400-w M-V	378	65.3	100-w M-V	225	52.9
1000-w M-V	897	66.4	250-w M-V	116	57.0
Total	1842	67.4		393	55.6

As shown in Table 3, a higher percentage of females appeared to be attracted to the lower than to the higher intensities.

Studies on Height of Traps. Studies to determine if the height of traps influenced the proportion of the sexes captured were conducted in 1954. Six traps were placed at a height of four feet and six at 12 feet. Unidirectional traps each equipped with a 15-watt BL lamp were used. These traps were in a barnyard at some distance from corn.

TABLE 4

Sex of June-flight corn borer moths taken at traps placed at heights of 4 and 12 feet. Tippecanoe County, Indiana. June 10-23, 1954. All traps equipped with 15-w BL lamps.

Height of Traps	No. Moths	Per Cent Females
4 feet	262	37
12 feet	309	51

As shown in Table 4, 51 per cent of the moths taken at the 12-foot traps were females and only 37 per cent of those taken at the 4-foot ones were.

Effect of Wind Direction on Sex Ratio. In 1954 a series of unidirectional traps in which four faced north, four east and four west were operated from June 10 to 23. During this time the wind was mostly from the south-east. The traps were placed in a barnyard at some distance from corn.

TABLE 5

Sex of June-flight corn borer moths taken at unidirectional traps facing different directions. Tippecanoe County, Indiana. June 10-23, 1954. All traps equipped with 15-w BL lamps. Wind mostly from south-east.

Direction Traps Faced	No. Moths	Per Cent Females
East	169	38
North	217	47
West	185	49

As shown in Table 5 more males than females came to the trap facing into the wind and about equal numbers of males and females came to the ones facing away from the wind.

Summary. Although the average sex ratio of European corn borer moths taken at light traps over a number of years is about 50:50, the results obtained in the studies reported here show that it varies rather widely from year to year and from generation to generation in the same locality, and from locality to locality in the same year. The results reported also show that more females than males are attracted to lamps which emit most of their energy in the ultraviolet region of the spectrum; that a higher percentage of females are attracted to lamps of low intensity than to those of higher; that traps placed at a height of 12 feet captured a higher percentage of females than did those placed at a height of four feet; and that about equal numbers of cruising males and females were taken at unidirectional traps facing away from the wind but that more males than females came to traps facing into the wind.

The Orders Protura and Diplura in Indiana[1]

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Protura

Insofar as this writer is aware the order Protura has not been recorded previously from Indiana. Neither Mills (6) nor Ewing (4) gave Indiana collection records although several species have been recorded from Illinois by the latter author. Proturans, because of their small size and rather restricted habitats, have undoubtedly been overlooked by collectors since members of this order are widely distributed.

On December 13, 1954 samples of leaf litter and soil were collected northwest of West Lafayette in a small woodland known locally as McCormick's Woods. The collected material was placed in a Berlese funnel and about eight adult proturans were taken in this manner. Additional material taken from this same site on December 18, 1954 and January 2, 1955 yielded many additional specimens including adults (the females with large eggs in the oviducts), tritonymphs and deutonymphs. The species has been tentatively identified as *Eosentomon pallidum* Ewing but a series has been submitted to specialists in the U. S. National Museum for determination.

These collections are interesting from the standpoint of seasonal occurrence. Ewing (4) reported on the seasonal distribution of *E. pallidum* taken in Maryland, Virginia, Pennsylvania, Illinois and Arkansas and had no records of the species in December and January although his data gave evidence that adults were present all year. That author also stated "That reproduction in this species for the latitudes involved continues for much of the year . . . reproduction activities are greater during the spring months." The observations made here would confirm those of Ewing, and in addition, would indicate that the species overwinters in both the nymphal and imaginal stage.

Diplura

The order Diplura is represented in Indiana by two families, Campodeidae and Japygidae. The insects belonging to this order may be characterized by being primitively apterous and by having long multisegmented antennae and conspicuous cerci which are segmented in the Campodeidae and forceps-like in the Japygidae. The mouthparts are of the chewing type and are entognathous. Their development is without metamorphosis.

Comparatively few records of their occurrence have been published although they are of wide distribution. Two species, one in each family, have been recorded from Indiana.

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[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1043.

Plusiocampa cookei (Packard).—Packard (7) reported the presence of this species in "the Wyandotte Caves." Silvestri (8) apparently referred to this species when he wrote "Per ora si deve far notare la presenze delle due specie *Campodea fragilis* Mein. e *C. plusiochaeta* Silv., che sono molto diffuse anche in Europa, e nelle grotte del' Indiana specie del genere *Plusiocampa* Silv., molto diffuso nelle grotte d'Europa." Blatchley (1) referred to the record of Packard but stated that he was unable to find the species during his investigations of Wyandotte Cave. Wolf (10) cited Packard's record but placed the species as *Campodea staphylinus* var *cookei.*

Campodea plusiochaeta Silvesti.—This species has been met with most frequently and has been taken in widely separated areas. The first specimen was taken December 13, 1954 in the litter and soil samples from McCormick's Woods, the samples which also yielded the Protura. A second individual was captured May 12, 1955 in discarded plant material outside a greenhouse near West Lafayette. On September 9, 1956 ten individuals were taken (many more escaped) from a clump of soil dug from a barn lot on the W. S. Lemon property at Friendship (Ripley Co.). These were collected primarily in and about the nest tunnels of the bee, *Melissodes bimaculata* Lepeletier.

Campodea fragilis Meinert.—Seven individuals belonging to this species were taken two miles west of West Lafayette on August 17, 1956. These were taken during the excavation of a nest of *Melissodes bimaculata* from a culvert fill along a country road. The fill dirt contained small, loose clumps of grass clippings and it was within such clumps that all of the specimens were found.

Metajapyx subterraneus (Packard).—This large japygid was reported from Owen, Monroe and Lawrence counties by Young (11). That author has recorded the habitats in which it was found and has a figure of the species. On June 11, 1955, one specimen of *M. subterraneus* was taken from beneath a rock in a woodland bordered by Laughrey Creek. The woodland lies south of Friendship (Ripley Co.) on the W. S. Lemon Farm.

Parajapyx minimus (Swenk).—Originally described by Swenk (9) "from among the roots of wheat growing in damp soil" in southeastern Nebraska, this species has been frequently observed at both West Lafayette and Friendship. The first individuals were observed during the summer of 1953 at West Lafayette in the nest tunnels of *Halictus ligatus* Say, a social halictine bee which nests gregariously in the soil. Since at that time research was being conducted on the life history of the bee (2), few specimens of *P. minimus* were taken but observations were made on its habits which indicated that it was either a scavenger in the empty brood cells or possibly a predator on the smaller arthropods present, principally mites.

On April 20, 1954, two specimens were taken from a nest of the acrobat ant, *Crematogaster lineolata* Say. The ants were nesting in the soil of a railroad embankment about one half mile west of West Lafayette. During the excavation of a nest of *Melissodes bimaculata* at

Friendship on September 9, 1956, three additional specimens were taken along with *Campodea plusiochaeta.*

Japyx sp.—Macklin (5) has recorded a number of individuals as *Japyx* sp. during studies of the soil fauna in a red clover field located about five miles northwest of Lafayette. His records are as follows (all for 1953): April 6 (30 specimens); June 23 (13 specimens); July 7 (record of occurrence but no numbers); July 28 (21 specimens); August 13 (8 specimens); September 29 (7 specimens). Estimates of the number of individuals per cubic foot of soil ranged from 171 in September to 512 in July.

In determining his specimens to the genus *Japyx* he undoubtedly used the name in its broadest sense as given by Comstock (3). More than likely the species was *Parajapyx minimus* which would appear to be very common throughout the Lafayette area.

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Records of Indiana Coleoptera, I

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Intensive collecting of Coleoptera in Tippecanoe County, Indiana, began with the 1952 season and has continued until the present. Additional collections were made in Parke County and the dunes region of Porter County. During 1945, some specimens were also taken in Bartholomew County. Most of the beetles were identified by using Blatchley's Coleoptra of Indiana (1) and special monographs and keys. A few families were worked over by specialists, including M. C. Lane of Walla Walla, Washington, and H. F. Howden of Knoxville, Tennessee. C. A. Frost of Framingham, Massachusetts, also examined many of the specimens.

As a result of this study, 75 species are listed here which are not recorded by Blatchley as being present in Indiana. A few of these Indiana records do appear in the revisional monographs of specialists and several are also noted in Montgomery's list of the Coleoptera of the Clarke County State Forest (3). Many of the listings in Blatchley are based upon single records. The following list includes records of 52 species which had been recorded from only one locality previously.

It is difficult to judge as to just how representative of the beetles of Indiana were the species which Blatchley had at hand. As shown on page 4 of the Coleoptera of Indiana (1) the most intensive collecting upon which his work was based took place in the extreme northern counties, the extreme southern counties, Marion County, and in Vigo and adjacent counties. As one uses Blatchley's book, one keeps noting over and over again the number of such entries as "not found north of Marion County," "southern third of the state," etc. Many of these beetles previously noted only in southern Indiana appear commonly in the northern part of the state. Whether these differences are brought about merely because of poor sampling on Blatchley's part or are related to the northward spread of animal species associated with a general warming up of the climate is difficult to tell. Perhaps, both are related to the problem. At any rate in the list below appear 160 new records of Coleoptera for northern Indiana. In addition to all of the above, records are noted on a few of the rarer species of the state.

To save space in the lists below the months will be abbreviated Ap., M., Je., Jl., Au., S., and O. Also Tippecanoe will be noted as T., Bartholomew as B., Parke as P., and the sand dunes of Porter County as SD. The numbers and nomenclature of Leng's Catalog and supplements (2) are used throughout. Species not noted in Blatchley as being recorded in Indiana are marked with an asterisk (*).

CARABIDAE

171 *Carabus serratus* Say...T; Ap-M

339 *Dyschirius sphaericollis* Say ...T; M-Je

342 *D. erythrocerus* Lec...T; M

355 *D. hispidus* Lec...T; M, P; Ap

363 *Clivina punctigera* Lec... B; Je

366 *C. rufa* Lec...B; Je

383 *Schizogenius lineolatus* Say ...T; Ap-Je, Common

385 *S. ferrugineus* Putz...T; Ap-Je, S.

395 *Ardistomis viridis* (Say)... T; Ap-Je, Common

408 *Bembidion inaequale* Say ...T; M

440 *B. laevigatum* Say...T; Ap

512 *B. nigrum* Say...P; M-Jl

572 *B. picipes* (Kby.)...T; M

737 *B. quadrimaculatum* (L.) ...T; M

744 *B. pedicellatum* Lec...T; Ap

792 *Pericompsus ephippiatus* (Say)...T; M, O

1058 *Evarthrus sodalis* (Lec.) ...T; Ap-Je

1067 *E. sigillatus* (Say)...T; Ap-Jl

1105 *Abacidus permundus* (Say) ...T; M, O

1110 *Gastrosticta obscura* (Say) ...P; M

1177 *Dysidius purpuratus* Lec ...T; Ap

1262 *Leiocnemis avida* (Say)... T; Je

1444 *Rembus obtusa* Lec...T; Jl, O

1466 *Dicaelus ambiguus* Laf... T; M-Je

1489 *Pristodactyla impunctata* (Say)...T; Je

1541 *Agonum mutatum* G. & H. ...T; M

1609 *Atranus pubescens* Dej... T; M

*1650 *Lebia divisa* Lec...T; Je

1666 *L. lobulata* Lec...T; Je

1671 *L. analis* Dej...T; M-Jl; very common

1672 *L. fuscata* Dej...T; Je

1691 *Dromius picipes* Dej...T; Je, O

1699 *Microlestes nigrinus* Mann ...P; M

1725 *Pinacodera limbata* (Dej.) ...T; Jl

1726 *P. platicollis* (Say)...P; Ap-M

*1753 *Apenes lucidula* (Dej.)... T; Je-S

1760 *Pentagonica flavipes* (Lec.) ...T; M

1770 *Helluomorpha bicolor* Harr ...T; M, S-O

1831 *Chlaenius leucoscelis* Chevr ...T; M-Je; P; M

1884 *Nothopus zabroides* Lec... T; Au

1895 *Pharalus indianus* Csiski ...T; S

1934 *Harpalus laticeps* Lec...T; M

1971 *H. nitidulus* Chd...T; M

2017 *Selenophorus gagatinus* Dej ...SD; Je, B; Jl

2039 *S. pedicularius* Dej...T; Ap-M

2089 *Anisodactylus melanopus* Hald...P; M

2107 *A. coenus* Say...B; Jl

2143 *Anisotarsus nitidipennis* Lec...T; Ap

DYTISCIDAE

*2607a *Copelatus chevrolati australis* Schf...T; Je-Jl

HYDROPHILIDAE

2810 *Hydrobius melaenum* Germ ...P; Jl

*2813 *Sperchopsis tesselatus* Zieg ...T; S-O, SD; Je

STAPHYLINIDAE

*3298 *Siagonium americanus* Melsh...T; Jl
*3305 *Triga picipennis* Lec...T; M, P; M
3461 *Geodromicus brunneus* (Say)...T; M, O, Common
3462 *G. strictus* Fauv...T; M, O, P; O
3556 *Apocellus sphaericollis* (Say)...T; M
3571 *Oxytelus sculptis* Grav... T; S-O
3711 *Stenus bipunctatus* Er...T; Ap-M, Common
3712 *S. colon* Say...T; Ap-M, P; Ap-Au
3727 *S. femoratus* Say...T; Ap-Jl, P; M, B; Je
3736 *S. erythropus* Melsh...T; O
*3746 *S. ingratus* Csy...B; M-Au
3787 *S. stygicus* Say...T; M-O, P; M
3812 *S. alacer* Csy...P; Au
3846 *S. arculus* Er...T; M, B; Jl
3928 *Hesperobium cinctum* (Say) T; Ap-M
3966 *Lathrobium armatum* Say ...T; Jl
*4022 *Tetartopeus angularis* (Lec.)...P; M
4093 *Aderocharis' corticina* Grav ...P; M-Au
*4094 *Lithocharis ochracea* (Grav.)...T; S-O
*4238 *Stilicus opaculus* Lec...T; S
*4240 *S. latiusculus* Csy...T; Au
4248 *S. dentatus* Say...T; M-S
4304 *Gyrohypnus fuscipes* Lec ...T; M
4347 *Leptolinus rubripennis* Lec. ...T; M-Au, B; M
4366 *Neobisnius jocusus* (Horn) ...T; M-O
*4369 *N. terminalis* (Lec.)...T; Ap-M, S
4384 *Philonthus politus* (L.)... T; O
*4387 *P. sericinus* Horn...T; O
4412 *P. umbrinus* Grav...T; Ap-M
4420 *P. debilis* Grav...T; Je
*4421 *P. varians* (Payk.)...T; Ap, SD; Je
4423 *P. longicornis* Steph...T; Ap-O
4431 *P. fulvipes* (F)...T; Ap-M
4470 *P. nigritulus* (Grav.)...T; Ap-Je
*4488 *P. viridanus* Horn...P; Ap
4514 *Belonuchus formosus* Grav ...T; Jl-O
4543 *Staphylinus fossator* Grav T; Jl
4564 *Acylophorus flavicollis* Sachse...T; M, P; O
4633 *Oxyporus stygicus* Say... T; Ap
4663 *Tachinus flavipennis* Dej... T; Jl
4678 *Tachyporus maculipennis* Lec...T; M-Je
4719 *Boletobius dimidiatus* Erichs...T; Jl
4724 *B. anticus* Horn...P; Au

HISTERIDAE

6530 *Hololepta aequalis* Say... T; M, P; M
6554 *Hister biplagiatus* Lec... T; M-Je, Common, SD; Je
6571 *H. interruptus* Beauv...T; Ap
6591 *H. marginicollis* Lec...T; Ap
*6612 *H. curtatus* Lec...T; M
6624 *H. sedecimstriatus* Say... T; M
6627b *H. americanus exaratus* T; Jl, on fungi
6632 *H. pollutus* Lec...T; Ap
6891 *Saprinus fitchii* Mars...T; Ap-Je

LYCIDAE

*6916 *Lycostomis lateralis* Melsh ...T; Jl

6935 *Eros thoracicus* (Rand.)... T; M

6940 *E. sculptilis* (Say)...T; Je

CANTHARIDAE

7162 *Silis latilobus* Blatch...T; Ap-Jl, Common, Grant; M

7180 *Malthodes exilis* Melsh... T; M

MELYRIDAE

7277 *Anthocomus flavilabrus* Say ...T; M

7279 *Pseudobacus apicalis* (Say) ...T; Ap-Je

7304 *Attalus pallifrons* Mots... T; Je

7306 *A. melanopterus* Er...T; Je

7322 *A. scincetus* (Say)...T; M-Je

CLERIDAE

7516 *Monophylla terminalis* (Say)...T; Jl

7544 *Cymatodera bicolor* Say... T; Je-Jl

7566 *C. undulata* (Say)...T; Jl-S

*7573 *Lecontella cancellata* (Lec.) ...T; Je

*7580 *Derestenus melanopterus* (Dury)...T; Je

*7596b*Enoclerus nigripes rufiventris* Spin...T; Ap, P; M

7597 *E. rosmarus* Say...T; M-Jl, Very common

7610 *E. quadrisignatus* (Say)... T; Je

7637 *Phyllobaenus unifasciatus* (Say)...T; Je

*7643 *P. pubescens* (Lec.)...T; Je

7647 *P. humeralis* (Say)...B; Je

7677 *P. pallipennis* (Say)...T; M-Jl, Common

7688 *Isohydnocera curtipennis* (Newn.)...T; Je

7689 *I. tabida* (Lec.)...T; Je, B; Je

7696 *Phlogistosternus dislocatus* (Say)...T; Je-Jl, Common on hickory

*7698 *Neichea laticornis* (Say)... T; Je-Jl, on hickory

7708 *Chariessa pilosa* Forst...T; Jl

*7711 *Corinthiscus leucophaeum* Klug...T; Je-Jl, Black walnut

7716 *Cregya oculata* Say...T; Je-Jl, Common

7719 *Orthopleura damicornis* F T; Je-Jl

CUPESIDAE

7744 *Cupes concolor* Westw... T; Je-Jl, on elm

OEDEMERIDAE

7788 *Oxacis taeniata* (Lec.)... T; Je-Jl

7799 *Asclera Puncticollis* (Say) ...T; M, B; M

MORDELLIDAE

7804 *Glipa bidentata* (Say)...T; Je

7807 *G. hilaris* (Say)...B; Jl

7814 *G. octopunctata* (F.)...T; Jl

7821 *G. oculata* (Say)...T; Jl

7824 *Tomoxia triloba* (Say)... T; Je-Jl, Common

7827 *T. discoidea* (Melsh.)...T; Je-Jl, B; Jl

*7830 *Conalia helva* (Lec.)...T; Jl

7838 *Mordellistena trifasciata* Say...T; Je, B; Jl

7848 *M. vapida* (Melsh.)...T; Je-Jl

*7855 *M. fulvicollis* (Melsh.)... T; Je-Jl

7859a *M. cervicalis* Lec...T; M-Je

*7872b *M. andrea ustulata* Lec... T; Jl

*7875 *M. semiusta* Lec...T; Jl, B; Jl
7894 *M. ambusta* Lec...T; Jl, B; Jl
7910 *M. pubescens* (F.)...T; Je, Common
7912 *M. liturata* (Melsh.)...T; Je-Jl, Common

RHIPIPHORIDAE

7950 *Macrosiagon dimidiatum* (F.)...T; Jl
7956 *M. limbatum* (F.)...T; Jl, Common on daisies, Queen Anne's lace

MELOIDAE

7998 *Epicauta atrata* (F)....T; Jl-Au, Common on wild roses; garden asters
*8145 *Meloe perplexus* Lec...T; O
8148 *M. americanus* Leach...T; Ap-M
8191 *Nemognatha vittigera* Lec ...Kosciusko; Au

PEDILIDAE

8250 *Pedilus labiatus* (Say)... T; M-Je, Common
8279 *Macratria murina* (F.)... T; Jl, Common

ANTHICIDAE

8283 *Notoxus bicolor* Say...T; M-S, Common
8334 *Tomoderus constrictus* (Say)...T; S
8348 *Anthicus cinctus* Sat...T; S
*8360 *A. nitidulus* Lec...T; Je
8387 *A. floralis* (L.)...T; Je-Jl
*8423 *A. thomasi* Pic...T; Ap-Je, P; Ap

EUGLENIDAE

*8475 *Elonus basalis* (Lec.)...T; Je-Jl
8476 *E. nebulosus* (Lec.)...T; Jl
8477 *Emelinus melsheimeri* (Lec)...T; Jl
8484 *Zonantes fasciatus* (Melsh.) T; Je-Jl, Common

RHIPICERIDAE

8543 *Zenoa picea* (Beauv.)...T; Jl

ELATERIDAE

8609 *Conoderus bellus* (Say)... T; M-S, Very common
8628 *Limonius interstitialis* (Melsh.)...T; Je-Jl
8627 *L. confusus* Lec...T; Ap-Je, Very common
8639 *L. dubitans* Lec...T; Ap-M
8663 *Athous acanthus* (Say)... T; M-Je
8663b *A. acanthus maculicollis* Lec...T; Je-Jl
8667 *A. cucullatus* (Say)...T; Je-Jl
8728 *Ctenicera signaticollis* Melsh...Harrison; Je
*8779 *C. arata* Lec...T; Je
8797 *C. divaricata* (Lec.)...Harrison; Je
*8813 *Hamicrepidius decoloratus* Say...T; Je
8817 *H. bilobatus* (Say)...T; Jl
8832 *Negastrius striatulus* (Lec.) ...T; Je
8821 *N. exiguus* (Rand.)...T; Ap-Je, P; Ap, SD; Je
8844 *N. aestivus* (Horn)...T; Jl
8866 *Elater abruptus* Say...T; Je
8883 *Sericus silaceus* Say...T; Je
8893 *Agriotes pubescens* Melsh ...T; Je
8906 *Glyphonyx recticollis* (Say) ...T; Je-Jl, Common
8909 *G. quietus* (Say)...T; Je
*8936 *Ampedus sellatus* (Dej.)... T; M, Orange; Je

8956 *A. luteolus* (Lec.)...T; Jl

**A. melatoides* Brown...T; M-Je

9005 *Anchastus binus* (Say)...T; Jl

9024 *Melanotus blatchleyi* Leng...T; M-Jl

9025 *M. ignoblis* (Melsh.)...T; Jl

9061 *M. polisus* Blatch...T; M-Je, Common

MELASIDAE

9130 *Stethon pectorosus* Lec...T; Je-Jl

*9134 *Deltometopus rufipes* (Melsh.)...T; Jl

9147 *Fornax calceatus* (Say)...T; Ap-M

9154 Microrhagus pectinatus Lec...T; Je

9156 *M. imperfectus* Lec...T; Je

9157 *M. triangularis* Say...T; Jl

9159 *M. bonvouloiri* Horn...T; Jl

9166 *Nematodes atropus* Say...T; Jl

*9173 *Hypocoelus terminalas* Lec...T; Jl

THROSCIDAE

9182 *Drapetes geminatus* Say...T; Je

BUPRESTIDAE

9291 *Ptosima gibbicollis* Say...T; M-Je

9323 *Chalcophorella campestris* (Say)...T; Je-Jl, Apple

9355 *Cinyra gracilipes* (Melsh.)...T; Jl

*9372 *Buprestis nuttalli consularis* Gory...Harrison; Je

*9374 B. rufipes (Ol.)...T; Jl, Honey locust

*9399 Agrilazia flavimanna (Gory)...T; Jl

9405 *Chrysobothris sexsignata* (Say)...T; Je-Jl

9408 *C. lecontei* Leng...T; Je

9499 *Agrilus difficilis* Gory...T; Je-Jl, Common on honey locust

9500 *A. ferrisi* Dury...T; Je

9504 *A. anxius* Gory...T; Jl

*9514 *A. lateralis* (Say)...B; Je

9515 *A. masculinus* Horn...T; Je, Common

*9517 *A. defectus*...T; Je

*19662 *A. celti* Knull...T; M-Je, Very common on hackberry

9537 *A. putillus* Say...T; Je-Jl Common on maple

9553 *A. lecontei* Sand...T; Je-Jl, Common

*19663 *A. egeniformis* C. & K....T; Je-Jl, Common

*21065 *A. transimpressus* Fall...T; Je

*21067 *A. olentangyi* C. & K....T; M

**A. cladrastus* Knull...T; M-Je

**A. cliftoni* Knull...T; Je-Jl

DRYOPIDAE

*9605 *Helichus striatus* Lec...T; Ap

ELMIDAE

**Stenelmis sexlineata* Sand...B; Je-Au, P; O

**S. decorata* Sand...T; Je, B; Je

HETEROIDAE

9645 *Heterocerus ventralis* Melsh...T; M-O, P; M-O

HELODIDAE

9687 *Helodes pulchella* Guer...T; Je

9709 *Scirtes orbiculatus* (F.)...T; Je-Jl

DERMESTIDAE

*9734 *Dermestes frischi* Kug...SD; Je

NITIDULIDAE

Carpophilus sayi Pars...T; Jl, SD; Je, B; Jl

10060 *C. antiquus* (Melsh.)...T; M

**Nitidula carnaria* Schall... T; Je, SD; Je

10101 *Prometopia sexmaculata* (Say)...T; Je, P; Je

10117 *Pocadius helvolus* Erichs ...T; Jl

CUCUJIDAE

*10200 *Silvanus quadricollis* Guer ...T; Je, B; Jl

10209 *Nausibius clavicornis* (Kug.)...Harrison; Nov

EROTYLIDAE

10314 *Tritoma angulata* Say...T; Jl

10328 *Triplax flavicollis* Lac...T; Je

CRYPTOPHAGIDAE

10370 *Antherophagus ochraceus* Melsh...Warren; Au

MYCETOPHAGIDAE

10501 *Mycetophagus pluripunctatus* Lec... T; Je

10508 *M. obsoletus* Melsh...P; M

10513 *Litargus balteatus* Lec... T; Je-Jl

10517 *L. didesmus* Say...T; Jl, Very common

COCCINELLIDAE

10979 *Brachyacantha quadripunctata* Melsh...T; Je-Jl

11028 *Scymnus melsheimeri* Weise...T; M-Je

11035 *S. puncticollis* Lec...T; Je

ALLECULIDAE

11250 *Hymenorus melsheimeri* Csy...T; Jl

11255 *H. obscurus* Say...T; Je-Jl

11267 *H. discretus* Csy...T; Je-Jl

*11310 *Isomira pulla* (Melsh.)... T; M-Je

11314 *I. oblongula* Csy...T; M-Je, Common on buckeye

TENEBRIONIDAE

*12301 *Rhipidandrus flabellicornis* (Sturm.)...T; Je

12360 *Alphitobius disperinus* (Panz.)...T; Je-Jl

12391 *Xylopinus aenescens* Lec... T; Jl

12393 *Haplandrus fulvipes* (Hbst.)...T; Jl

12415 *Neatus picipes* (Hbst.)... T; Je

12433 *Paratenetus fuscus* Lec... T; Je-Jl

12488 *Strongylium tenuicolle* Say ...T; Je-Jl, B; Je

12489 *S. terminatum* Say...T; Je-Jl, B; Jl

MELANDRYIDAE

12535 *Eustrophus tomentosus* Say...T; Je

12546 *Orchesia castanea* Melsh... T; Je-Jl, Common

12567 *Enchodes sericea* (Hald.) ...T; Jl

ANOBIIDAE

12734 *Xyletinus peltatus* (Harr.) ...T; Je-Jl, Common

12752 *Petalium seriatum* Fall... T; Je

12761 *Eupactus nitidus* Lec...T; Je-Jl, Common

BOSTRICHIDAE

12919 *Stephanopachys punctatus* (Say)...T; Ap-Jl, Common

LYCTIDAE

12934 *Lyctus parallelopipidus* (Melsh.)...T; Jl, B; Je

12940 *L. planicollis* Lec...T; M. Elkhart

SCARABAEIDAE

13052 *Canthon viridis* (Beauv.)...T; M

13057 *Choeridium histeroides* (Web.)...T; M-Jl, Decaying fungi

*13107 *Aphodius fossor* (L.)...T; M

13255 *Pleurophorus caesus* (Cr.)...T; Ap-Je

**Diastictus batesi* Arrow...T; M

**Bolbocerosoma bruneri* D. & Mc...T; Je

13293 *Geotrupes blackburni excrementi* Say...T; Ap

*13298 *G. semiopacus* Jek...T; M-Jl

13296 *G. opacus* Hald...T; M

13320 *Cleotus aphodiodes* (Ill.)...T; Jl

13344 *Trox scaber* (L.)...B; M-Je

*13346 *T. laticollis* Lec...T; Ap

*13409 *Diplotaxis tristis* Kby...P; M

13497 *Phyllophaga futilis* Lec...T; Common, SD; Je

13652 *Dichelonyx diluta* Fall...T; Je

13653 *D. fuscula* Lec...T; M-Jl, Common on hickory

13694 *Hoplia trifasciata* Say...T; Ap-Je, P; Ap

13695 *H. trivialis* Har...T; Ap

13697 *H. limbata* Lec...Brown; Je

13720 *Anomala flavipennis* Burm...T; M-Je, B; Je

*13938 *Euphoria herbacea* (Oliv.)...Knox; M

13973 *Cremastocheilus canaliculatus* (Kby.)...T; Ap-M, Common sandy fields

13995 *C. knochi* Lec...T; Ap-M, Common along with the above

14012 *Osmoderma eremicola* Knoch...T; Je-Jl

14031 *Valgus canaliculatus* (F.)...T; Je, Common

LUCANIDAE

14062 *Nicagus obscurus* (Lec.)...T; Ap-Je, Common sandy banks of streams

CERAMBYCIDAE

14177 *Tylonotus bimaculatus*...T; Je-Jl

14220 *Elaphidion mucronatum* (Say)...T; Jl

14263 *Pseudibidion unicolor* (Rand.)...T; Je-Jl

14271 *Heterachtes quadrimaculatus* (F.)...T; Je

14286 *Obrium maculatum* (Oliv.)...T; Jl, On hickory

14291 *O. rufulum*...T; Je-Jl

14320 *Toxotus cinnamopterus* (Rand.)...T; Je

14405 *Acmaeops directa* (Newn.)...T; Je, Common

14407 *Acmaeops bivittatus* (Say)...T; M

*14456 *Grammoptera exigua* (Newn.)...T; Je, Common

14459 *G. subargentata* (Kby.)...T; Je

14465 *Leptura lineola* Say...T; M-Je

*14544 *Typocerus acuticauda* Csy...T; Je-Jl, Common

*14463 *Charisalia americana* (Hald.)...T; Je

14525 *Anoplodera proxima* (Say)...T; Je

14438 *A. rubica* (Say)...T; Je

14586 *Callimoxys fuscipennis* (Lec.)...T; Je

**Callidium schotti* Schffr...T; Jl

14666 *Cyllene decora* Oliv...Boone; S

14704 *Neoclytus mucronatus* (F.)...T; Jl

14730 *Clytanthus albofasciatus* (Lap.)...T; Je
14755 *Rhopalophora longipes* Say ...T; Je, Common
14796 *Purpuricenus axillaris* Hald ...Clark; Je
14909 *Dorcaschema alternatum* (Say)...T; Je-S, Common on mulberry
14932 *Aegoschema modesta* (Gyll.)...T; Jl, On maple
14943 *Leptostylus tuberculatus* Frol...T; Je-Jl
14960 *Astylopsis macula* (Say) ...T; Je-Jl, Very common
Astylidius versutus downiei Dillon...T; Jl, P; Au
14968 *Liopus variegatus* (Hald.) ...T; Je-Jl, Common on honey locust
*14994 *Lepturges confluens* (Hald.)...T; Je-Jl, Common on black walnut
*14994a *L. angulatus* Lec...T; Je
14995 *L. symmetricus* (Hald.)... T; Je-Jl
14997 *L. regularis* Lec...T; Je
14998 *L. signatus* Lec...T; Je-Jl, Common
15003 *L. facetus* Say...T; Je, On apple
15005 *Hyperplatys maculata* Hald ...T; Jl, On apple
15098 *Hippopsis lemniscata* (F.) ...T; Je-Jl
*15121 *Saperda puncticollis* Say ...T; M
15134 *Oberea schaumi* Lec...T; Je, On willow
15152 *O. Ocellata* Hald...T; Je
15158 *Tetrops monostigma* (Hald.)...T; Je
15186 *Hemicrania marginata* (F.) ...T; Je

CHRYSOMELIDAE

15229 *Zeugophora scutellatus* Suffr...T; Jl
15259 *Lema sayi* Cr...T; M
15308 *Griburius scutellaris* (F.) ...T; Je, Brown; Je
15487 *Cryptocephalus leucomelas* Suffr...T; Je-S, Common on willow
15514 *C. badius* (Suffr.)...T; Je
15547 *Nodonota convexa* (Say) ...T; Je
15577 *Fidia viticida* Walsh...T; Je-Jl, Very common on grape
15578 *F. longipes* (Melsh.)...T; Je, On grape
15590 *Metachroma interruptum* (Say)...T; Je, Very common
15608 *Myochrous denticollis* (Say)...T; M-Je
15614 *Glyptoscelis barbata* (Say) ...T; M-Jl, Common on hickory
15626 *Typophorus viridicyaneus* Cr...T; Je-Jl, Very common on bindweed
*15699 *Phaedon viridis* (Melsh.) ...Kosciusko; M
15703 *Gastroidea cyanea* Melsh ...T; Ap-M
15752 *Galerucella tuberculata* (Say)...T; Ap-M, Common on willow
15762 *Paratriarius dorsata* (Say) ...T; Je, Common
15850 *Phyllecthrus gentilis* Lec ...T; Je
15860 *Pachyonychus paradoxus* Melsh...T; Je-Jl
15885 *Oedionychis thyamoides* Cr ...T; Ap-Je
*15886 *O. circumdata* Rand...T; Je
Disonycha procera Csy... B; Je
Disonycha alternata (Ill.) ...T; Ap-O, On willow
15910 *D. mellicollis* (Say)...T; Jl
15924 *Altica cuprescens* Blatch... ...T; Je

15965 *Trichaltica scabricula* Cr ...T; M-Je

15969 *Crepidodera erythropus* Melsh...T; M

16029 *Systena marginalis* (Ill.) ...T; Common on oak

16058 *Glyptina cyanipennis* Cr... T; M

16077 *Phyllotreta lewisi* (Cr.)... T; S, Common on Cleome

16123 *Octotoma plicatula* (F.)... T; M-Je

16129 *Microrhopala vittata* (F.) ...T; Jl

BRUCHIDAE

*16175 *Bruchus discoideus* Say... T; Je

16222 *B. hibisci* Oliv...T; Ap-Je, Very common

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The Anthophilous Insects of Indiana

1. A preliminary annotated list of the Apoidea[1]

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Several thousand specimens of anthophilous insects have been collected during the past six years in the course of a study of the ecology of bumble bees, including their relationships to flowers of all types and to the other insects which also visit flowers. A majority of these specimens are bees, although a considerable number of other Hymenoptera, many flies, some beetles and a few insects of other groups are also included.

These bees appear to be representative enough of the fauna of the state to form the basis of a preliminary state list, especially as only a few scattered records of Indiana bees (except bumble bees) have been published.

The first records of Indiana bees appeared in 1837 in a posthumous paper by Thomas Say (14). Seventeen of the species of bees described in this paper are listed from Indiana in Say's usual laconic style of giving distribution, "Inhabits Indiana." Cresson's catalogue (9) lists Indiana for only three species of bees, all based on Say's records, although the ranges described for some other species include the state. There would appear to have been little collecting of bees in Indiana following Say's work as I have been able to find records of only sixteen other species before 1950. However, Cockerell (7) in listing two species from Lafayette, noted that these were collected by "Lutz and associates during their explorations of the western states." If this "expedition" yielded other specimens of bees from Indiana they apparently have not been noted in literature.

Franklin (11) listed nine species of bumble bees as occurring in Indiana, although he seemed to have based his listing on known ranges including the state for four species and to have had definite records of five; he questioned the occurrence of *B. ternarius* in Indiana. Viereck (15) described one species from the state; Cockerell in a series of papers (6, 7, 8) described one species and one variety—both named "*indianensis*"—and recorded three other species from Indiana. Lutz and Cockerell (12) quoted (from Say, Franklin and Cockerell, 1914) records of 11 species from Indiana. The Synoptic Catalogue of the Hymenoptera of America North of Mexico (13) lists "Ind." in the distribution of 22 species of bees, of which 10 are copied from previous authors, and 12 appear to be based upon previously unpublished records or upon published papers unacknowledged in the Catlogue and which the author has not noted.

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[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1048.

Three rather extensive studies of bees as pollinators have been carried on as thesis investigations at Purdue University in recent years. Howard R. Youse studied the collection of pollen by honey bees and prepared a thesis (16), entitled "A Contribution to the Taxonomic Study of Pollen Grains Collected by Honey Bees in Indiana." He listed 194 genera of plants upon which honey bees were observed by him or by co-operating beekeepers. He gathered and studied the characteristics of the pollen from one or more species of 153 of these genera and published (17) on 60 species which he considered as the more important sources of honey bee-collected pollen in Indiana. Plant genera among the 194 listed by Youse and not recorded in the collections or observations of the author have been incorporated in the host plant list for *Apis mellifera* without further acknowledgment.

Leland Chandler carried on a study of alfalfa pollination in selected fields in Tippecanoe and Marshall counties during the summer of 1950 and prepared a thesis (1) based upon his investigations. This thesis included an appendix entitled, "The Bombidae of Indiana," and consisting of some general information on bumble bees, and keys, descriptions and records of the Indiana species. These records were published (2), and three later papers (3, 4, 5) by the same author have included additional records and notes on Indiana bumble bees.

Studies extending over several years formed the basis of another thesis by Chandler (1955) on "The Ecological Life History of *Halictus (H.) ligatus* Say with Notes on Related Species." In addition to the life history studies this paper lists host plants and the seasonal range for *H. ligatus* and a few "related" species.

The following annotated list has been compiled by combining the records from the literature reviewed above with those based upon specimens in the Purdue University collections, especially material collected in the course of pollination studies since 1950.[2]

The nomenclature and sequence of the Synoptic Catalogue of Hymenoptera of America (13) has been followed. The genera of the Catalogue have been numbered (1-98), the subgenera when grouped have been lettered ("a", "b", etc.) within each genus, and the species have been numbered by page of the catalogue for use in reference and arrangement.

For each species, except for bumble bees and the honey bee, known distribution within the state is listed by counties, season distribution by earliest and latest dates of collection, and plants from which bees have been collected are listed by genera following the nomenclature and sequence of Deam (10). County records without plant host are starred (*) if not otherwise evident. Since Chandler's papers (1, 2, 3, 4, 5) give complete information on the county and seasonal records of

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[2] Almost all of the determinations have been made or checked by specialists—some of the earlier specimens and records by the late Grace Sandhouse and Theodore Frison, the current collections by T. B. Mitchell, Karl V. Krombein, Wallace LaBerge *(Mellisodes)* and Leland Chandler (Bombini, and a few other Apidae). Valuable assistance in the determination of plants has been given by A. T. Guard and George Cummins.

Indiana bumble bees these are not repeated here, and as honey bees are present in every part of the state and fly whenever the temperature is high enough only plant records are given for this species.

List of Species

COLLETIDAE

COLLETINAE

3. COLLETES Latreille

1045. *C. americanus* Cresson. Spencer; Sept. 10-18; Polygonum, Mentha, Eupatorium, Solidago.

1045. *C. compactus* Cresson. *Cass, Spencer, Tippecanoe, *Warren; Sept. 5-16; Eupatorium, Solidago, Rudbeckia.

1046. *C. eulophi* Robertson. Tippecanoe, White; June 16-Sept. 10; Melilotus, Solidago.

1046. *C. inaequalis* Say. (Indiana-Say, 1837), Clinton, Grant, Tippecanoe; April 1-May 7; Salix, Claytonia, Stellaria, Gypsophila, Pyrus, Prunus, Cercis, Taraxacum.

1047. *C. latitarsus* Robertson. Clark, Tippecanoe; July 20-Aug. 10; Trifolium.

1047. *C. kincaidii* Cockerell. (Ind.-Hym. Am.)

1047. *C. nudus* Robertson. Tippecanoe; July 30; Mentha.

1048. *C. simulans armatus* Patton. Spencer; Sept. 10; Eupatorium.

1048. *C. solidaginis* Swenk. (Ind.-Hym. Am.)

HYLAEINAE

4. HYLAEUS Fabricius

1050. *H. (Hylaeus) cressonii* (Cockerell). Clark, Spencer, Tippecanoe; June 3-Sept. 14; Melilotus, Evonymus, Eryngium, Daucus, Leonurus, Mentha, Solidago.

1050. *H. (H.) ellipticus* (Kirby). Tippecanoe; May 22; Gypsophila.

1051. *H. (Prosopis) modestus* Say. *Carroll, Cass, Clark, Gibson, *Marshall, Putnam, Spencer, Tippecanoe, *Warren; June 8-Sept. 20; Hydrangea, Rosa, Trifolium, Hibiscus, Eryngium, Pastinaca, Daucus, Leonurus, Pycnanthemum, Mentha, Gerardia, Campanula, Eupatorium, Solidago.

1052. *H. (P.) teleporus* (Lovell). Tippecanoe; July 3; Salvia.

1052. *H. (P.) ziziae* (Robertson). Cass, Gibson, *Marshall, Tippecanoe; June 3-Sept. 18; Brassica, Agastache, Salvia, Pycnanthemum, Cephalanthus, Solidago, Erigeron.

ANDRENIDAE

ANDRENINAE

5. ANDRENA Fabricius

1055. *A. (Trachandrena) albofoveata* (Graenicher). Tippecanoe; April 3-6; Salix, Stellaria.

1057. *A. (Pterandrena) asteris* Robertson. Tippecanoe; Sept. 5; Rudbeckia.
1058. *A. (Cryptandrena) belfragei* Cresson. Tippecanoe; April 19; Salix, Pyrus.
1058. *A. (?Micrandrena) bipunctata* Cresson. Carroll, Gibson, Grant, Madison, Tippecanoe, Tipton, Warren; April 1-May 24; Salix, Claytonia, Stellaria, Gypsophila, Pyrus, Malus, Amelanchier, Prunus, Viburnum, Taraxacum.
1058. *A. (Thysandrena) bisalicis* Viereck. Gibson, Madison, Tippecanoe; April 1-28; Salix, Claytonia, Stellaria.
1060. *A. (Cryptandrena) carlini* Cockerell. Madison, Tippecanoe, *Warren; April 6-28; Salix, Claytonia, Stellaria, Lonicera.
1062. *A. (Gymnandrena) commoda* Smith. *Johnson, Tippecanoe, *Warren; June 16-July 1; Melilotus.
1062. *A. (Schizandrena) crataegi* Robertson. Tippecanoe; April 24-May 24; Gypsophila, Malus, Prunus, Viburnum.
1063. *A. (Opandrena) cressonii* Robertson. Grant, Tippecanoe; April 14-27; Salix, Claytonia, Pyrus.
1064. *A. (Cryptandrena) dunningi* Cockerell. Tippecanoe; April 3-May 10; Salix, Stellaria, Malus.
1065. *A. (Ptilandrena) erigeniae* Robertson. Madison, Tippecanoe; April 18-May 21; Claytonia, Gypsophila.
1065. *A. (Cryptandrena) erythrogaster* (Ashmead). Cass, Clinton, Grant, *Martin, Tippecanoe, Warren; April 19-May 7; Salix, Malus, Prunus, Amelanchier, Crataegus, Taraxacum.
1065. *A. (Trachandrena) fenningeri* Viereck. Tippecanoe; April 29; Taraxacum.
1065. *A. (T.) forbesii* Robertson. Grant, Tippecanoe; April 14-May 22; Salix, Gypsophila, Prunus, Taraxacum.
1066. *A. (Gonandrena) fragilis* Smith. Tippecanoe; June 8; Pastinaca,
1067. *A. (Pterandrena) helianthi* Robertson. *Lake, Tippecanoe; July 19-Aug. 16; Tagetes.
1067. *A. hirticincta* Provancher. Marshall; Sept. 14; Aster.
1068. *A. (Micrandrena) illinoiensis* Robertson. Clinton, Grant, Tippecanoe, Warren; April 3-May 7; Salix, Amelanchier, Crataegus, Taraxacum.
1068. *A. (M.) imitatrix* Cresson. Tippecanoe, Warren; April 14-May 7; Salix, Pyrus, Amelanchier, Crataegus, Prunus.
1068. *A. (Trachandrena) indianensis* Cockerell. (Monroe-Cockerell, 1929.)
1069. *A. (Thysandrena) lata* Viereck. Tippecanoe; April 14; Salix.
1071. *A. (Trachandrena) mariae mariae* Robertson. Tippecanoe; April 14-27; Salix.
1071. *A. (T.) mariae concolor* Robertson. Tippecanoe; April 14-19; Salix, Pyrus.
1072. *A. (T.) morrisonella* Viereck. Tippecanoe; April 24-May 24; Salix, Gypsophila, Malus, Prunus.
1074. *A. (T.) nuda* Robertson. *Tippecanoe, Warren; April 20-June 4; Amelanchier.

1077. *A. (Leucandrena) placida* Smith. Tippecanoe; April 20; Salix.
1078. *A. (Cryptandrena) pruni* Robertson. Tippecanoe; April 14-24; Prunus.
1079. *A. (?Gonandrena) robertsoni* Dalla Torre. Putnam; June 26; Trifolium.
1079. *A. (Trachandrena) rugosa* Robertson. Tippecanoe; April 5-24; Salix, Cercis.
1080. *A. (Micrandrena) salictaria* Robertson. Tippecanoe; April 20; Salix.
1080. *A. (Gymnandrena) sayi* Robertson. Gibson, Tippecanoe, Warren; April 19-20; Salix, Stellaria, Amelanchier, Pyrus, Prunus.
1081. *A. (Trachandrena) spiraeana* Robertson. Clark; June 20; Hydrangea.
1083. *A. (Andrena) thaspii* Graenicher. (Ind.-Hym. Am.)
1084. *A. (Cryptandrena) virburnella* Graenicher. Grant, Tippecanoe, Warren; April 12-May 7; Salix, Claytonia, Amelanchier, Crataegus, Malus, Prunus.
1085. *A. (Gymnandrena) vicina* Smith. Tippecanoe; April 14-19; Salix.
1085. *A. (Cryptandrena) wilkella* (Kirby). Hendricks, Porter, *Pulaski, Putnam, Tippecanoe, Wells; April 29-July 16; Cotoneaster, Medicago, Melilotus, Trifolium, Robinia, Salvia, Taraxacum.

PANURGINAE

10. PERDITA Smith

1091. *P. gerhardi gerhardi* Viereck. (Lake; Aug. 28; Monarda-Viereck, 1904.)
1091. *P. lacteipennis indianensis* Cockerell. (Tippecanoe; Aug. 16-Cockerell, 1922.)
1092. *P. maura* Cockerell. (Tippecanoe; Aug. 16-Cockerell, 1922, as *P. bisignata.)*

12. PSEUDOPANURGUS Nylander

12c. Heterosarus Robertson

1099. *P. (H.) compositarum* (Robertson). Tippecanoe; Oct. 12; Aster.
1100. *P. (H.) labrosus* (Robertson). Tippecanoe; Aug. 14.

14. CALLIOPSIS Smith

1103. *C. (Calliopsis) andreniformis* Smith. Tippecanoe; June 14-Aug. 16; Raphanus, Trifolium, Malva, Citrullus, Cucumis.

HALICTIDAE

HALICTINAE

16. HALICTUS Latreille

16a. Halictus Latreille

1104. *H. (H.) ligatus* Say. Cass, Carroll, Clark, Clinton, Gibson, Grant, Lawrence, Spencer, Tippecanoe, Warren, White; May 7-Oct. 12; Brassica, Melilotus, Trifolium, Malva, Eryngium, Nepeta, Monarda, Pycnanthemum, Mentha, Cephalanthus, Eupatorium, Solidago, Aster, Erigeron, Helianthus, Calendula, Tagetes, Zinnia, Cirsium, Taraxacum.

1105. *H. (H.) parallelus* Say. (Indiana-Say, 1837), Carroll, Gibson, Jefferson, Warren; July 12-Sept. 16; Gypsophila, Melilotus, Trifolium, Cephalanthus, Sambucus, Solidago, Taraxacum.

1105. *H. (H.) rubicundus* (Christ). Clark, Morgan-Monroe, Porter, Tippecanoe; April 3-Sept. 5; Salix, Hydrangea, Prunus, Melilotus, Trifolium, Malva, Eupatorium.

16b. Seladonia Robertson

1105. *H. (S.) confusus* Smith. Carroll, Clinton, Hendricks, Tippecanoe, Warren; April 1-Sept. 5; Salix, Brassica, Prunus, Lotus, Melilotus, Trifolium, Malva, Hibiscus, Eryngium, Agastache, Salvia, Mentha, Solidago, Erigeron, Tagetes, Taraxacum.

17. LASIOGLOSSUM Curtis

17a. Lasioglossum Curtis

1106. *L. (L.) coriaceum* (Smith). *Clark, Tippecanoe, *Wells; April 19-July 8; Mertensia, Salvia.

1106. *L. (L.) forbesii* (Robertson). Tippecanoe; April 14-July 7; Salix, Melilotus, Taraxacum.

1106. *L. (L.) fuscipenne* (Smith). Clark; Aug 13; Viburnum.

17b. Evylaeus Robertson

1107. *L. (E.) arcuatum* (Robertson). Morgan-Monroe only, Tippecanoe, April 3-Aug. 25; Salix, Stellaria, Gypsophila, Hydrangea, Malus, Melilotus, Viburnum.

1107. *L. (E.) parisum* (Lovell). Clark; Aug. 13; Viburnum.

1108. *L. (E.) foxii* (Robertson). Morgan-Monroe, Tippecanoe, Warren; April 20-July 16; Amelanchier, Prunus, Melilotus.

1108. *L. (E.) macoupinense* (Robertson). Clark; July 13.

1109. *L. (E.) pectorale* Smith. Clark, *Daviess, Fulton, Tippecanoe; May 21-Oct. 31; Brassica, Malva, Eryngium, Asclepias, Agastache, Solidago, Aster, Tagetes.

1110. *L. (E.) truncatum* (Robertson). Morgan-Monroe; April 14-July 15; Salix, Melilotus.

17c. Hemihalictus Cockerell

1110. *L. (H.) lustrans* (Cockerell). Marshall; June 2; Taraxacum.

17e. Chloralictus Robertson

1111. *L. (C.) albipenne* (Robertson). Clinton, Tippecanoe; July 21-Aug. 21; Agastache, Citrullus, Taraxacum.

1112. *L. (C.) bruneri* (Crawford). *Clark, Tippecanoe; June 3-Aug. 12; Gladiolus, Evonymus.

1113. *L. (C.) coeruleum* (Robertson). *Clark, Madison; April 28-July 28; Claytonia.

1113. *L. (C.) cressonii* (Robertson). Allen, *Clark, Tippecanoe; June 3-Aug. 25; Evonymus, Salvia, Malva, Cirsium.

1113. *L. (C.) coreopsis* (Robertson). Clark, Gibson, *Jackson, Tippecanoe; April 14-Aug. 12; Salix, Pycnanthemum, Solidago, Calendula.

1114. *L. (C.) illinoense* Robertson. *Clark, *Daviess, *Jackson, Morgan-Monroe, Spencer, Tippecanoe, *Wells; April 4-Sept. 16; Polygonum, Prunus, Phaseolus, Ricinus, Malva, Asclepias, Salvia, Mentha, Eupatorium, Solidago, Taraxacum.

1114. *L. (C.) lineatulum* (Crawford). Tippecanoe; April 20; Salix.

1114. *L. (C.) unicum* (Sandhouse). Clark, Morgan-Monroe, Spencer, Tippecanoe; June 24-Sept. 18; Polygonum, Sida, Mentha, Eupatorium, Solidago, Tagetes.

1115. *L. (C.) obscurum* (Robertson). Clinton, Morgan-Monroe, Tippecanoe, Warren; April 15-Aug. 5; Salix, Brassica, Trifolium, Ricinus, Malva, Eryngium, Agastache, Salvia, Taraxacum.

1115. *L. (C.) planatum* (Lovell). Clinton, Tippecanoe; April 15-July 13; Brassica, Taraxacum.

1116. *L. (C.) pilosum* (Smith). Clinton, *Daviess, *Jackson, Marshall, Tippecanoe, Warren; April 14-Sept. 23; Gladiolus, Salix, Prunus, Medicago, Trifolium, Malva, Cirsium, Taraxacum.

1117. *L. (C.) pruinosum* (Robertson). Tippecanoe; July 26-27; Gladiolus, Mentha.

1117. *L. (C.) reticulatum* (Robertson). Spencer; Sept. 11; Sida.

1118. *L. (C.) stultum* (Cresson). Carroll, *Clark, Clinton, *Daviess, Gibson, Grant, Hendricks, Morgan-Monroe, Porter, Putnam, Tippecanoe, Warren; April 1-Sept. 14; Gladiolus, Salix, Gypsophila, Brassica, Raphanus, Hydrangea, Prunus, Baptisia, Melilotus, Trifolium, Evonymus, Malva, Eryngium, Pastinaca, Daucus, Agastache, Leonurus, Salvia, Mentha, Cephalanthus, Sambucus, Citrullus, Cirsium, Tagetes, Taraxacum.

1118. *L. (C.) tegulare* (Robertson). Clark, *Daviess, Tippecanoe; April 1-July 30; Salix, Gypsophila, Citrullus, Solidago.

1118. *L. (C.) versatum* (Robertson). Carroll, Clinton, *Daviess, Gibson, *Jackson, Madison, Tippecanoe, Tipton; April 14-Oct. 31; Salix, Brassica, Prunus, Ricinus, Malva, Pcynanthemum, Aster, Taraxacum.

1118. *L. (C.) zephyrum* (Smith). Morgan-Monroe, Tippecanoe, Warren; April 18-Sept. 25; Salix, Prunus, Hydrangea, Cercis, Malva, Viburnum, Helianthus, Cirsium.

17g. Paralictus Robertson

1119. *L. (P.) playparium* (Robertson). Tippecanoe; April 4; Salix.

19. SPHECODES Latreille

1120. *S. arvensis* Patton. (Ind.-Hym. Am.), Tippecanoe; April 21; Taraxacum.

1120. *S. confertus* Say. (Indiana-Say, 1837.)

1121. *S. heraclei* Robertson. Clark; July 29; Solidago.

1121. *S. illinoensis* (Robertson). (Ind.-Hym. Am.)

1121. *S. mandibularis* Cresson. Tippecanoe; July 20; Cucumis.

1123. *S. ranuculi* Robertson. Carroll; June 4.

1123. *S. stygius* Robertson. Morgan-Monroe; July 15; Melilotus.

20. AGAPOSTEMON Guerin-Meneville

1124. *A. radiatus* (Say). (Indiana-Say, 1837), Gibson, Jefferson, Morgan-Monroe, Tippecanoe; April 14-Oct. 12; Salix, Prunus, Melilotus, Trifolium, Althaea, Elaeagnus, Hibiscus, Pycnanthemum, Aster, Tagetes.

1124. *A. splendens* (Lepeletier). *Clark, Morgan-Monroe, *Pulaski; June 28-Aug. 2; Melilotus.

1125. *A. virescens* (Fabricius). Gibson, Lawrence, Marshall, Morgan-Monroe, Tippecanoe, Williams (Ohio); May 20-Sept. 14; Gladiolus, Stellaria, Medicago, Melilotus, Rhus, Althaea, Malva, Hibiscus, Salvia, Cucurbita, Cucumis, Vernonia, Aster, Helianthus.

21. AUGOCHLORA Smith

21a. Augochlora Smith

1125. *A. (A.) pura* (Say). *Clark, *Johnson, *Lawrence, Tippecanoe; June 19-Aug. 26; Malva, Cucurbita, Tagetes.

21b. Augochlorella Sandhouse

1125. *A. (A.) aurata* Smith. Spencer, Tippecanoe, Warren; April 29-Sept. 11; Polygonum, Raphanus, Lotus, Melilotus, Trifolium, Malva, Sida, Agastache, Nepeta, Salvia, Monarda, Citrullus, Taraxacum.

1125. *A. (A.) gratiosa* Smith. Tippecanoe; July 7; Malva.

1126. *A. (A.) striata* Provancher. Clark, Clinton, Gibson, *Owen, Spencer, Tippecanoe, Warren; April 14-Sept. 20; Salix, Rosa, Melilotus, Lathyrus, Lotus, Malva, Sida, Agastache, Salvia, Monarda, Aureolaria, Cephalanthus, Cucurbita, Citrullus, Cucumis, Chrysanthemum, Taraxacum.

22. AUGOCHLOROPSIS Cockerell

1126. *A. cuprea* (Smith). Clark, Gibson, Tippecanoe; April 9-Aug. 2; Prunus, Melilotus, Tilia, Pycnanthemum, Lycopersicum.

NOMIINAE

23. NOMIA Latreille

23d. Dieunomia Cockerell

1129. *N. (D.) heteropoda valida* (Say). Starke; Sept. 10; Eupatorium.

MEGACHILIDAE

MEGACHILINAE

33. PARANTHIDIUM Cockerell and Cockerell

1138. *P. (Paranthidium) jugatorium jugatorium* (Say). (Indiana-Say, 1837, as *Stelis obesa.)*

37. ANTHIDIELLUM Cockerell

1146. *A. notatum* (Latreille). Tippecanoe; Sept. 5; Nepeta.

44. PROCHELOSTOMA Robertson

1152. *P. philadelphi* (Robertson). Noble; June 20.

45. HERIADES Spinola

45b. Neotrypetes Robertson

1152. *H. (N.) variolosa variolosa* (Cresson). Tippecanoe; Aug. 25; Brassica.

46. ASHMEADIELLA Cockerell

1153. *A. (Ashmeadiella) bucconis bucconis* (Say). (Indiana-Say, 1837.)

49. HOPLITIS Klug

49c. Alcidamea Cresson

1158. *H. (A.) producta* (Cresson). Tippecanoe; June 16; Trifolium.

53. OSMIA Panzer

53a. Osmia Panzer

1163. *O. (O.) lignaria* Say. Tippecanoe, Tipton, *Warren; April 3-May 13; Salix, Mertensia, Taraxacum.

53b. Chalcosmia Schiedeknecht

1163. *O. (C.) coerulescens* (Linnaeus). Morgan, Tippecanoe; June 3-July 5; Trifolium, Lotus, Salvia.

53f. Nothosmia Ashmead

1167. *O. (N.) albiventris* Cresson. Tippecanoe; July 7; Agastache.
1167. *O. (N.) atriventris* Cresson. Tippecanoe; June 20; Hydrangea.
1170. *O. (N.) pumila* Cresson. Tipton; April 28; Taraxacum.
1171. *O. (N.) simillima* Smith. Tippecanoe; July 7-16; Vicia, Malva.

54. MEGACHILE Latreille

54a. Litomegachile Mitchell

1172. *M. (L.) brevis* Say. (Indiana-Say, 1837), Carroll, Gibson, Greene, Jefferson, Lake, Marshall, Spencer, Tippecanoe; June 16-Oct. 12; Medicago, Trifolium, Lespedeza, Lotus, Phaseolus, Malva.
1172. *M. (L.) cleomis* Cockerell (Ind.-Hym. Am.)
1172. *M. (L.) mendica* Cresson. *Clark, *Fulton, Gibson, Jackson, Jefferson, Marshall, Tippecanoe, Wells; June 20-Sept. 20; Medicago, Trifolium, Lespedeza, Phaseolus, Gerardia.
1172. *M. (L.) texana* Cresson. Marshall; Aug. 23; Medicago.

54f. Delomegachile Viereck

1174. *M. (D.) gemula* Cresson. Marshall; Aug. 23; Lotus.

54j. Xeromegachile Mitchell

1177. *M. (X.) integra* Cresson. Tippecanoe; Aug. 29.

54k. Argyrophile Mitchell

1179. *M. (A.) parallela parallela* Smith. (Ind.-Hym. Am.)

54*l*. Xanthosarus Robertson

1179. *M. (S.) latimana* Say. Carroll, Gibson, Grant, Greene, Howard, Jay, Johnson, Marshall, Morgan, Spencer, Tippecanoe, *Union, Warren, Wells, White; July 5-Sept. 16; Medicago, Trifolium, Lotus, Verbena, Liatris, Solidago, Aster, Helianthus, Cirsium.

54m. Leptorachis Mitchell

1180. *M. (L.) petulans* Cresson. *Carroll, *Clark, Gibson, Morgan-Monroe, Tippecanoe, White; June 26-Sept. 5; Melolitus, Phaseolus, Verbena, Marrubium, Liatris.

54o. Acentron Mitchell

1180. *M. (A.) albitarsis* Cresson. White; Aug. 9; Liatris.

54q. Sayapis Titus

1181. *M. (S.) frugalis* Cresson. *Clark, Tippecanoe; June 19-July 13; Lathyrus, Lotus.
1181. *M. (S.) inimica sayi* Cresson. (Ind.-Hym. Am.)
1181. *M. (S.) pugnata* Say. (Indiana-Say, 1837), Tippecanoe; June 24-July 7; Agastache, Nepeta, Helianthus.

54r. Chelostomoides Robertson

1182. *M. (C.) campanulae* Robertson. *Clark, Gibson, Tippecanoe; June 28-July 13; Lathyrus, Verbena.
1182. *M. (C.) exilis parexilis* Mitchell. (Ind.-Hym. Am.), Tippecanoe; July 7; Marrubium.

55. COELIOXYS Latreille

1183. *C. alternata* Say. (Indiana-Say, 1837.)
1184. *C. banksi* Crawford. (Ind.-Hym. Am.)
1184. *C. germana* Cresson. Gibson, *Morgan-Monroe; June 24-July 11; Verbena.
1185. *C. immaculata* Cockerell. (Miners, Indiana; July-Cockerell, 1912.)
1185. *C. altilis* Cresson. Spencer; Sept. 11; Sida.
1185. *C. modesta* Smith. (Ind.-Hym. Am.), Gibson; July 12; Pycnanthemum.
1186. *C. rufitarsus* Smith. Marshall; Aug. 23; Lotus.
1186. *C. sayi* Robertson. (Ind.-Hym. Am.), *Clark, Gibson, Morgan-Monroe, Tippecanoe; June 24-Sept. 20; Melilotus, Lespedeza, Lotus, Verbena, Agastache, Nepeta, Cephalanthus.

APIDAE

ANTHOPHORINAE

58. NOMADA Scopoli

58b. Gnathias Robertson

1195. *N. (G.) lepida* Cresson. Grant; April 27; Prunus.
1196. *N. (G.) perplexa* Cresson. Clark; June 14.

58d. Heminomada Cockerell and Atkins

1199. *N. (H.) luteola* Olivier. Tippecanoe; April 29; Taraxacum.

1199. *N. (H.) obliterata* Cresson. Gibson, Tippecanoe; May 4; Stellaria, Taraxacum.

58e. Holonomada Robertson

1201. *N. (H.) superba superba* Cresson. Tippecanoe; June 24; Salvia.

58g. Pachynomada Rodeck

1202. *N. (P.) vincta vincta* Say. (Indiana-Say, 1837.)

58k. Nomadula Cockerell

1205. *N. (N.) incerta* Cresson. Tippecanoe; June 16; Melilotus.

70. EPEOLUS Latreille

1211. *E. bifasciatus* Cresson. Tippecanoe; Aug. 13; Nepeta.

71. TRIEPEOLUS Robertson

1214. *T. concavus* (Cresson). Warren; Aug. 10; Monarda.
1214. *T. concolor* (Robertson). Gibson, Johnson, Tippecanoe, *Warren; July 11-Aug. 13; Melilotus, Malva, Verbena, Marrubium, Agastache, Nepta, Salvia, Pycnanthemum, Cephalanthus.
1214. *T. donatus* (Smith). Tippecanoe; Sept. 5.
1215. *T. lunatus* (Say). Gibson, Tippecanoe; July 11-Aug. 17; Trifolium; Malva, Verbena, Agastache, Nepeta, Helianthus.
1217. *T. remigatus* (Fabricius). Tippecanoe; July 7-Aug. 13; Malva, Agastache, Salvia, Cucumis, Helianthus, Tagetes.
1217. *T. simplex* Robertson. Gibson; July 11; Verbena.

73. EMPHOR Patton

1218. *E. bombiformis* (Cresson). *Fountain, Gibson, Tippecanoe; July 12-Aug. 28; Hibiscus, Cephalanthus.

75. MELITOMA Lepeletier et Serville

1221. *M. taurea* (Say). (Indiana-Say, 1837), *Clark, Gibson, *Johnson, Spencer, Tippecanoe; June 25-Sept. 11; Ipomoea.

76. PEPONAPIS Robertson

1221. *P. pruinosa* (Say). (Indiana-Say, 1837), Tippecanoe; July 24-30; Cucurbita, Citrullus.

77. XENOGLOSSA Smith

1221. *X. strenua* (Cresson). Tippecanoe; July 24-Aug. 25; Cucurbita.

81. FLORILEGUS Robertson

1222. *F. condignus* (Cresson). Fountain; July 24.

82. MELISSODES Latreille

1222. *M. agilis* Cresson. Tippecanoe; July 13; Helianthus.
1222. *M. agilis aurigeniae* Cresson. Tippecanoe; Aug. 25; Helianthus.
1223. *M. autumnalis* Robertson. White; Sept. 10; Solidago.
1223. *M. bimaculata* (Lepeletier). (Indiana-Say, 1837, as *Macrocera binotata*), Carroll, Clark, Clinton, Gibson, Greene, Hendricks,

Howard, Jay, Jefferson, Johnson, Marshall, Morgan, Posey, Tippecanoe, Warren; July 4-Aug. 28; Gladiolus, Melilotus, Trifolium, Phaseolus, Althaea, Malva, Hibiscus, Ipomoea, Agastache, Nepeta, Salvia, Monarda, Aureolaria, Cephalanthus, Cucurbita, Citrullus, Tagetes, Cirsium, Zinnia.

1224. *M. cnini* Robertson. Clinton, *Fulton, Tippecanoe; Aug. 21-Sept. 10; Cucurbita, Solidago, Cirsium.

1224. *M. communis* Cresson. *Fountain, Gibson, Posey, *Tippecanoe; July 11-Aug. 21; Trifolium, Verbena.

1224. *M. desponsa* Smith. Allen, Warren, White; Aug. 6-Sept. 10; Cirsium.

1227. *M. nivea* Robertson. *Lawrence, Spencer, Tippecanoe; July 30-Sept. 16; Solidago, Helianthus.

1227. *M. obliqua* (Say). (Indiana-Say, 1837), Clinton, *Gibson, Jasper, *Lawrence, Marshall, Spencer, Tippecanoe, Warren; July 23-Sept. 13; Trifolium, Euphorbia, Monarda, Vernonia, Helianthus, Tagetes, Cirsium.

1227. *M. pennsylvanica* (Lepeletier). Tippecanoe; July 28; Helianthus.

1228. *M. rustica* (Say). (Indiana-Say, 1837), Spencer, Tippecanoe, White; Sept. 5-11; Eupatorium, Solidago.

1229. *M. trinodis* Robertson. Lake; Aug. 1.

1229. *M. vernoniae* Robertson. Marshall; July 27-Sept. 14; Vernonia, Aster.

84. TETRALONIA Spinola

1232. *T. dubitata* (Cresson). Tippecanoe; June 3-9; Melilotus, Salvia.

1232. *T. dilecta* (Cresson). (Monroe-Cockerell, 1914), Tippecanoe; May 6-June 3; Trifolium, Robinia, Salvia.

1232. *T. hamata* Bradley. Tippecanoe; June 16; Trifolium.

86. ANTHOPHORA Latreille

86a. Anthophora Latreille

1234. *A. abrupta* Say. (Indiana-Say, 1837.)

86b. Clisodon Patton

1237. *A. furcata terminalis* Cresson. Clark, *Tippecanoe; June 3-Sept. 28; Salvia, Cephalanthus.

86c. Amegilla Friese

1237. *A. walshii* Cresson. Tippecanoe; Sept. 20; Campanula.

XYLOCOPINAE

93. CERATINA Latreille

93b. Zadontomerus Ashmead

1244. *C. (Z.) calcarata*[3] Robertson. Clark, Clinton, Grant, Marshall, Porter, Spencer, Tippecanoe; April 6-Sept. 5; Salix, Brassica,

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[3] As Michener (1936) has indicated the females of *C. calcarata* and *C. dupla* cannot be distinguished with certainty. However, both Krombein and Mitchell have tentatively named all specimens submitted in accordance with Sandhouse's key (1935). About 125 specimens have not been separated

Trifolium, Prunus, Malva, Hibiscus, Mertensia, Agastache, Leonurus, Salvia, Aureolaria, Cucurbita, Citrullus, Cucumis, Eupatorium, Tagetes, Taraxacum.

1244. *C. (Z.) dupla*[3] Say. (Indiana-Say, 1837), Cass, Clark, Grant, Marshall, Tippecanoe; April 4-Sept. 18; Salix, Prunus, Malva, Hibiscus, Salvia, Viburnum, Rudbeckia, Helianthus, Calendula, Taraxacum.

1245. *C. (Z.) metallica* H. S. Smith. Clark, Gibson, Spencer, Tippecanoe; April 19-Sept. 11; Mertensia, Pycnanthemum, Cephalanthus, Solidago.

94. XYLOCOPA Latreille

1246. *X. virginica* (Linnaeus). Spencer, Tippecanoe, Wells, *Warren; May-Sept. 11; Trifolium, Robinia, Phaseolus.

APINAE

96. BOMBUS Latreille

96a. Fraternobombus Skorikov

1247. *B. (F.) fraternus* (F. Smith). Trifolium (☿), Eupatorium (☿ ♂).

96b. Bombias Robertson

1247. *B. (B.) auricomus* (Robertson). Trifolium (♀ ☿ ♂), Cirsium (☿ ♂).

96c. Separatobombus Frison

1248. *B. (S.) griseocollis* (DeGeer). Hydrangea (☿), Trifolium (☿ ♂), Asclepias (☿), Cephalanthus (☿ ♂), Eupatorium (♂), Solidago (♂), Cirsium (♂).

96e. Subterraneobombus Vogt

1249. *B. (S.) borealis* Kirby.

96f. Fervidobombus Skorikov

1249. *B. (F.) americanorum* (Fabricius). Malus (☿), Trifolium Hibis- (♀ ☿ ♂), Phaseolus (☿ ♂), Sida (☿ ♂), Pycnanthemum (☿), Lycopersicum (☿), Cephalanthus (☿), Campanula (☿ ♂), Vernonia (☿ ♂), Aster (☿ ♂), Tagetes (☿ ♂), Cirsium (☿ ♂).

1249. *B. (F.) fervidus* (Fabricius), including var. *dorsalis* Cresson. Lotus (☿), Trifolium (♀ ☿ ♂), Monarda (☿), Eupatorium (☿ ♂), Cirsium (☿).

96g. Bombus Latreille

1250. *B. (B.) affinis* Cressen, including var. *novae-angliae* Bequaert.

1250. *B. (B.) terricola* Kirby.

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on this basis nor submitted for identification; the records of these may be summarized, as follows: Allen, Carroll, Gibson, Marshall, Spencer, Tippecanoe, Warren, Wells; April 14-Sept. 18; Gladiolus, Salix, Trifolium, Raphanus, Malva, Sida, Eryngium, Agastache, Nepeta, Leonurus, Monarda, Mentha, Cephalanthus, Cucurbita, Eupatorium, Aster, Tagetes, Cirsium.

96h. Pratobombus Vogt

1251. *B. (P.) bimaculatus* Cresson, including var. *ridingsii* Cresson, Hibiscus (☿ ♂).

1252. *B. (P.) impatiens* Cresson, including var. *deayi* Chandler. Polygonum (☿ ♂), Hydrangea (☿), Melilotus (♂), Trifolium (☿), Althaea (☿), Sida (☿), Asclepias (☿), Gerardia (☿), Cephalanthus (☿), Campanula (☿), Eupatorium (☿), Solidago (☿ ♂), Aster (☿ ♂), Tagetes (☿).

1252. *B. (P.) perplexus* Cresson.

1253. *B. (P.) ternarius* Say.

1253. *B. (P.) vagans* F. Smith, including var. *helenae* (Frison), Trifolium (☿), Solidago (☿).

97. PSITHYRUS Lepeletier

97b. Ashtonipsithyrus Frison

1254. *P. (A.) ashtoni* Cresson.

97c. Laboriopsithyrus Frison

1254. *P. (L.) insularis* (F. Smith).

1255. *P. (L.) laboriosus* (Fabricius), including var. *citrinus* (F. Smith) Melilotus (♀), Agastache (♀).

1255. *P. (L.) variabilis* (Cresson). Trifolium (♀), Vernonia (♂), Eupatorium (♂).

98. APIS Linnaeus

1255. *A. mellifera* Linnaeus.[4] Sagittaria, Phleum, Zea, Symplocarpus, Arisaema, Tradescantia, Allium, Lilium, Erythronium, Asparagus, Polygonatum, Trillium, Gladiolus, Populus, Salix, Juglans, Carya, Corylus, Quercus, Ulmus, Celtis, Morus, Maclura, Humulus, Rumex, Polygonum, Fragopyrum, Amaranthus, Phytolacca, Claytonia, Portulaca, Stellaria, Nymphaea, Caltha, Aquilegia, Delphinium, Anemone, Hepatica, Clematis, Ranunculus, Mahonia, Podophyllum, Berberis, Menispermum, Liriodendron, Asimina, Sassafras, Benzoin, Sanguinaria, Papaver, Dicentra, Lepidium, Sisymbrium, Brassica, Barbarea, Nasturtium, Dentaria, Conringia, Polanisia, Sedum, Deutzia, Philadelphus, Hydrangea, Ribes, Grossularia, Hamamelis, Chaenomeles, Cotoneaster, Physocarpus, Spirea, Pyrus, Malus, Aronica, Amelanchier, Crataegus, Rubus, Fragaria, Potentilla, Rosa, Prunus, Cercis, Gleditsia, Medicago, Melilotus,

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[4] Although the honeybee which was originally introduced into Indiana was *A. mellifera mellifera* from northern Europe, the extensive, almost universal, use of the "Italian" bees, *A. mellifera ligustica* Spinola by beekeepers in the state for fifty years has propably entirely replaced the typical variety of the species. Two other varieties, the Caucasian bee, *A. mellifera remipes* Gerstaecker, and the Carniolian bee, *A. mellifera càrnica* Butt.-Reep., have been used to some extent also. Recently, there has been a shift to so-called hybrid bees and although these strains have been developed very largely from Italian bees stocks of other "races," especially the Caucasian have been incorporated into the breeding lines.

Trifolium, Robinia, Desmodium, Vicia, Lathyrus, Soja, Lotus, Phaseolus, Geranium, Dictamnus, Zanthoxylum, Ptelea, Ailanthus, Ricinus, Euphorbia, Rhus, Ilex, Evonymus, Celastrus, Staphylea, Acer, Aesculus, Koelreuteria, Impatiens, Rhamnus, Vitis, Parthenocissus, Tilia, Althaea, Malva, Hibiscus, Hypericum, Viola, Epilobium, Oenothera, Pastinaca, Daucus, Cornus, Gaylussacia, Vaccinium, Clethra, Diospyros, Ligustrum, Fraxinum, Apocynum, Asclepias, Ampelamus, Gonolobus, Convolvulus, Ipomoea, Phlox, Hydrophyllum, Cynoglossum, Hackelia, Mertensia, Vitex, Verbena, Teucrium, Marrubium, Agastache, Nepeta, Glecoma, Prunella, Leonurus, Stachys, Salvia, Monarda, Hedeoma, Pycnanthemum, Lycopus, Nicotiana, Physalis, Solanum, Datura, Digitalis, Verbascum, Veronicastrum, Campsis, Catalpa, Dianthera, Plantago, Cephalanthus, Abelia, Kolkwitzia, Weigelia, Sambucus, Viburnum, Symphoricarpus, Lonicera, Dipsacus, Citrullus, Cucumis, Curcurbita, Echninocystis, Campanula, Vernonia, Eupatorium, Solidago, Aster, Erigeron, Ambrosia, Xanthium, Rudbeckia, Helianthus, Tagetes, Zinnia, Bidens, Helenium, Anthemis, Chrysanthemum, Tanacetum, Arctium, Cirsium, Taraxacum, Sonchus, Lactuca.

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Three Entomological Laboratory Techniques[1]

Department of Entomology, Purdue University

I. Rearing Method for Subterranean Termites........John V. Osmun[2]

II. Circulation Fans for Fumigation Chambers......Harry B. Moore[3] and John V. Osmun

III. Chambers for Exposure of Roaches to Chemically Treated Surfaces.......Frederick P. Diehl[4] and John V. Osmun

I. Rearing Method for Subterranean Termites

Progress in the study of the response of the subterranean termite, *Reticulitermes flavipes* (Kollar), to insecticides in the soil is dependent on a satisfactory method of rearing and handling these particular insects Several prerequisites are necessary: an environment with high constant humidity yet without free water, a wood supply free from excessive decay, a source of essential nutrients, rearing chambers which will accommodate large self-sustaining populations, and of major importance, a convenient method for removing the termites for use in experimental studies. Previously reported methods have all had certain limitations, although the use of agar by Light and Weesner (3) did supply a clue for the method finally developed and adopted in this study. After considerable trial and error, including the use of paper toweling and agar, and sawdust and agar, the following technique was adopted:

The equipment used consists of clear plastic crisper dishes 9¾ x 6 x 3¾ inches in size and fitted with clear plastic covers in which two small holes (7 mm. diameter) are drilled to permit the regulation of air exchange. Into each container is poured 250 ml. of 4.5% bacto-agar. After the agar has set, specially cut wood is introduced and placed on pieces of ¼ inch glass tubing to keep it from direct contact with the agar. The wood, aged southern yellow pine, is prepared from 2 x 4 inch boards cut in 6 inch lengths. Into the ends of each are drilled three evenly spaced ⅜ inch holes 3 inches deep. The pieces of wood are then ripped lengthwise cutting through the holes and dividing the wide face into four equal strips. These four are then bundled back together with two rubber bands so their final actual size is approximately 1⅝ x 3¼ x 6 inches. Each plastic chamber holds three bundles flat along the bottom and a second layer may be used if desired after the termite colony is established and needs more cellulose (Figure 1). The holes hasten termite penetration and acceptance of the wood. Termites are introduced into the chambers from strong, active colonies in the field. About 2,000 individuals appear to be the minimum number for a healthy colony in each of these chambers, and several thousand more can be accommodated. Effort is made to include, along with the workers, several mature secondary reproductives or a goodly number of nymphs of the reproductive caste together with a complement of soldiers. When introduced, the termites quickly tunnel the agar and later move from there into the wood. The rearing chambers are kept in a high humidity cabinet at 24±1° C, a temperature set for convenience in connection with the testing temperature rather than necessarily as an optimum for the termites. Maintenance of moisture is not a problem, although in one colony it was considered necessary to add, several months later, a ¼ inch sheet of 4.5% agar placed between the blocks of wood.

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[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1049.

[2] Based on research performed at the University of Illinois.

[3] Present address, Reliable Exterminators, Inc., West Lafayette, Indiana.

[4] Present address, 3803 Gettysburg Road, Camp Hill, Pennsylvania.

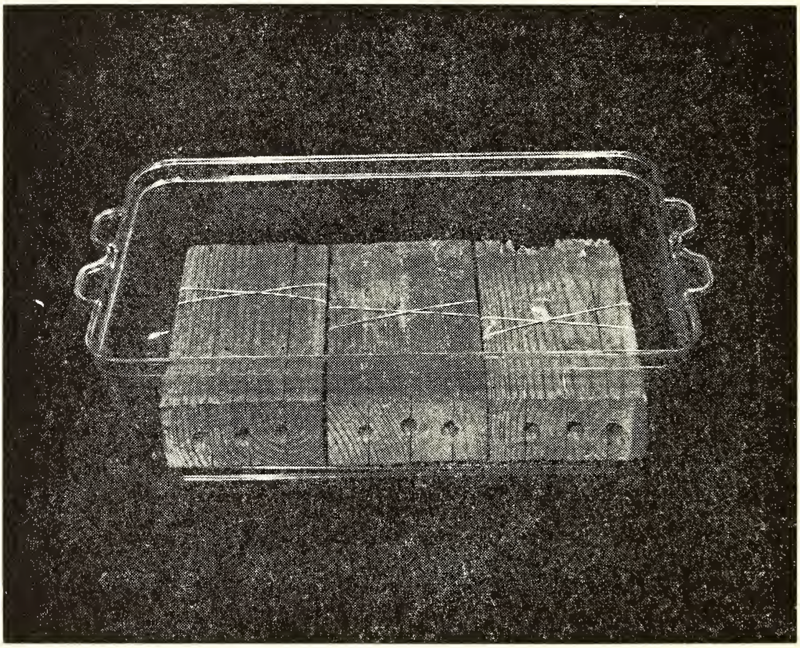

Figure 1

It has been found that maintaining termites in chambers with agar and "clean" wood alone is seldom successful. By introducing a thin layer of soil from the termites' natural environment onto the agar surface, the nutritional requirements other than that of cellulose seem to be satisfied. There is little doubt but what certain fungi must be present in the termite environment to furnish an adequate supply of protein and vitamin (Hendee (2), Hungate (3), Light and Weesner (4), DeLong (1)). Such fungi are present in the soil and in pieces of colonized wood. In colonies established most recently, 75 mg. of live dry yeast was sprinkled over the top of the wood after it was placed in the chambers. The basis of this action resulted from success experienced with recuperating small, waning colonies held in petri dishes.

The handling technique described has been used not only for maintaining an established colony but also for rearing termites through from eggs. Secondary reproductives are the principal source of eggs, but due to the long period of development it is impractical to count on such methods alone when large numbers of termites are required.

When termites are needed for testing, it has been very convenient to obtain them from the type of rearing chamber described. A bundle of wood is removed and carefully opened along the laminations without necessarily removing the rubber band. From the space occupied, termites are gently shaken into a petri dish. When sufficient termites are collected, the bundles of wood are replaced in the rearing chamber. The termites thus collected in the petri dishes are kept healthy with a little debris from the rearing chambers and a small piece of 4% agar. These termites are held until needed for tests, but for the sake of uniformity they are held in this manner no longer than one week.

During the course of the investigation, termites from three sources were used: a building in Indianapolis, Indiana; a board removed from the ground in Champaign, Illinois; and the experimental termite plots in Allerton Park, Illinois. The only extensive testing has been done with termites from the latter location. They were obtained for the laboratory by driving 2 x 4 x 18 inch stakes into the ground and leaving them for six months. These stakes were then pulled, brought back to the laboratory where the termites were removed and introduced into the rearing chambers described. An initial supply was obtained from a few stakes already in the ground. During the course of tests with topical applications, all three populations were tested to show to the author's satisfaction that no appreciable differences existed with respect to variation in susceptibility to insecticides.

II. Circulation Fans for Fumigation Chambers

Methods for testing the responses of insects to accurately measured quantities of fumigants have frequently been complicated by several factors. These factors include those associated with the desirability of employing relatively small chambers in which a minute amount of gas can be utilized without loss and yet it dispersed uniformally in the atmosphere of the chamber. Pressure cookers with air circulation pumps have been tried, but equipment expense and gas loss reduce their usefulness. Randall et al. (5) describes a method by which weighed amounts of gas were introduced into a bottle which was shaken frequently during the test to help distribute the gas uniformally.

In the method described here, 20-liter flint glass bottles were utilized. These containers are very suitable since they are a convenient size for testing quantities of insects, are air tight except for a small opening in the neck, and can be replicated without excessive need for space or equipment. As used in our research, the bottle opening is plugged with a rubber stopper immediately after the introduction of test cages containing insects and the test quantity of fumigant. The unique feature is the method of air circulation used to prevent gas stratification. A miniature electric fan is used in each chamber. The fan is powered by a 12-volt, direct current motor of the type used in model airplane and scale model trains. These motors are 1 inch in diameter and 1¾ inches long. Each motor is fitted with a four blade aluminum or plastic fan 1 inch in diameter. When used in fumigation tests, the fans are suspended inside the bottles 4 inches from the bottom of the chamber. The wire leads are fitted with soldered loops which allow them to be placed over wire hooks which in turn project through the rubber stoppers and convey the current from a transformer.

Since continuous circulation of air is detrimental to some test insects, the apparatus has been equipped with a time switch which permits intermittent fan activity. The equipment is illustrated in Figure 2.

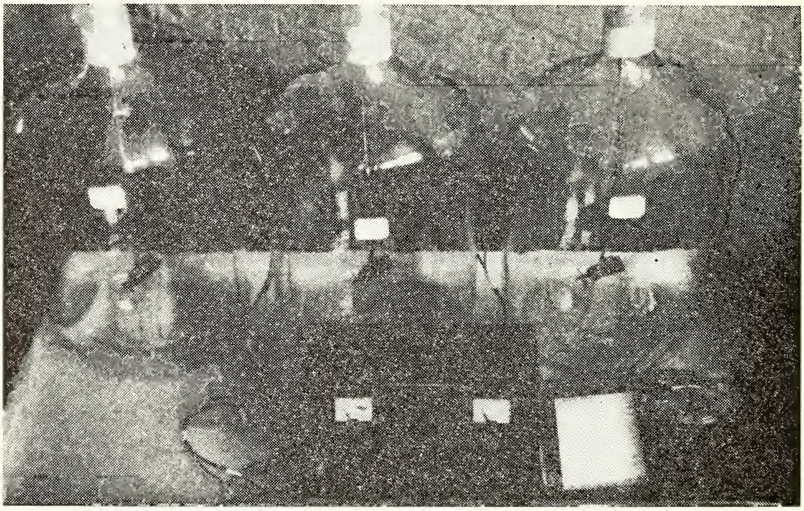

Figure 2

III. Chambers for Exposure of Roaches to Chemically Treated Surfaces

Methods of assaying biologically the insecticidal activity of treated surfaces has never been entirely satisfactory. This has been especially true when roaches have been the test insect involved. Prerequisites for such studies include having a test cage which will confine roaches to the treated surfaces continuously during the exposure period, and will permit observation as well as rapid removal of the insects at the end of the time interval. These observations could be made by using several hundred individual cages with various surfaces and chemical treatments, but the inconvenience and excessive expense would preclude such an approach. A properly designed cage into which could be placed differently treated surfaces would fulfill the needs.

In the course of our study dealing with the exposure of the German cockroach, *Blatella germanica* (L.), to chlordane treated surfaces, it was found that the following technique adequately met the requirements of the test. The basic unit of the test cage consists of two strips of grooved yellow pine, ½″ x 2″ x 9″. One of the 2″ sides of each piece of wood is double-grooved along its length, with the inside distance between the grooves being ¼ inch. These two strips serve as parallel sides of a frame holding the test panels. The test surfaces of each cage consist of two 6 x 6″ pieces of material, such as glass, metal, plywood, or painted wood (Figure 3). Two such test panels are inserted in grooves of the 2-sided frame in such a manner as to have the treated surfaces face each other. When a roach is placed within the quarter inch space provided, it must crawl on one treated surface or the other. The frames are held together by rubber bands, and the two end openings into the test area are closed with pieces of 2″ x 6″ observation glass slipped into suitable grooves provided in the frame. Such a device permits the

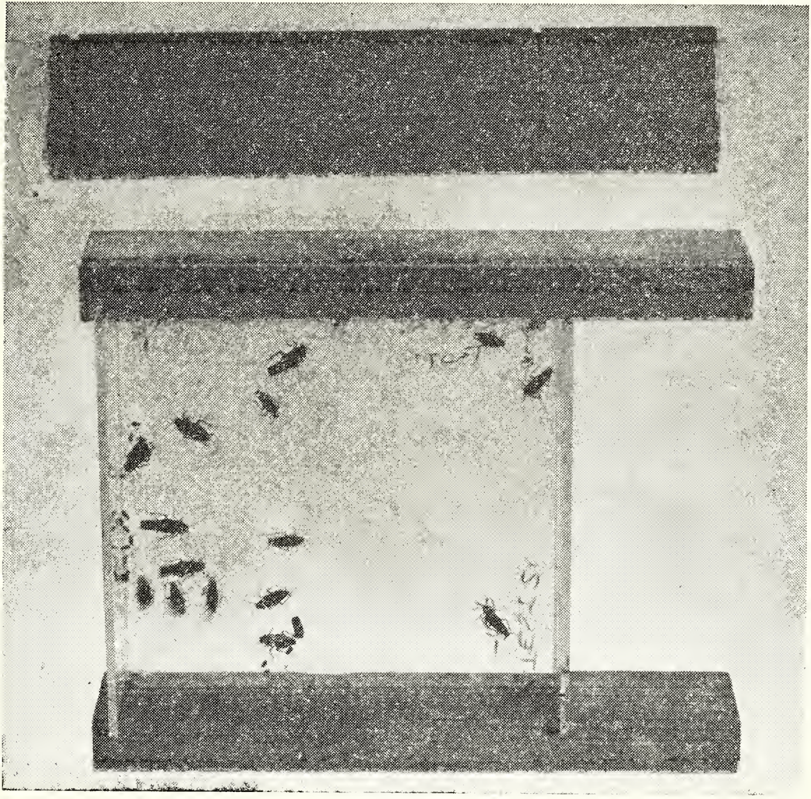
Figure 3

reuse, retreatment, cleaning, or discard of test panels. A few sets of frames will serve numerous test panels and treatments.

In test situations, the German roaches are anesthetized with CO_2 and placed on a small piece of clean paper. The paper is slipped into the test area and the front observation glass allowed to rest gently on it. When the insects regain consciousness, the paper is quickly withdrawn. At the end of the exposure period, CO^2 is introduced into the chamber and the reanesthetized roaches gently shaken out into holding dishes.

A modification of this test chamber was developed in which a large ¼" thick plastic ring, 6" in diameter, was substituted for the grooved wooden frame. Although this device is somewhat simpler to operate, its use is dependent on the availability of such plastic. Both types of cages permit continuous, natural contact of roaches with insecticide residues, and convenient observation of the toxicological responses.

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Wireworm Populations as Influenced by Soil Types[1,2]

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Investigations on the control of wireworms have resulted in the collection of specimens from many locations in Indiana and especially in the northern counties. While wireworms occur throughout the state and are commonly associated with poorly drained soils, information on distribution of the species in various soil types is meager. Blatchley (1) recognizes 147 species of Elateridae from the state, but provides little data on the host of the larval stage. Losses from these insects have been associated with four conditions: the species of wireworm present, soil type, soil drainage and crops grown in previous years. In this study, attention has been given to the identity of the species found in various fields as correlated to the soil type and the previous land use.

Our investigations have been confined largely to northern Indiana and more specifically, Starke county, for it is from those areas that complaints of losses have been received. Much of this area has poor soils, especially sand, interspersed with muck. Fields in Starke county are, in general, level and have poor drainage because of an impervious subsoil. The principal drainage system is the Kankakee river running along the north west side of the county and the Yellow river running from east to west through the center of the county. Muck areas are scattered throughout the county and range from a few up to 500 acres. According to a land use map prepared by the Starke County Land Use Planning Committee in the late 1930's, 42 percent of the land is low, dark sand; 31 percent bottom and valley; 12 percent high light sand; and 10 percent muck. The area along the Kankakee and the lower Yellow rivers was a part of the old Kankakee swamp and is subject to flooding. During the past six years there has been two major floods and two of lesser extent.

The common species of wireworms found in this area have a three year life cycle. In both the field and in laboratory rearings, adults changed from the pupal stage in late August or early September, and remained in the pupal cell all winter. Beetles emerged in April and May and reached the peak of activity in late May. In heavily infested areas beetles were observed crawling on the ground or in short flights a few feet in the air. Egg-laying occurred in late May and June, either in the field where the adults emerged or in nearby sod land. The eggs hatched in a few weeks and the young larvae fed on the roots of grass until fall. Winter months were apparently spent deeper

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[1] The author wishes to acknowledge the assistance of M. C. Lane, Entomology Research Branch, U. S. Department of Agriculture, Walla Walla, Washington, *in identifying* both larvae and adults of the species mentioned in this paper.

[2] Purdue University, Agricultural Experiment Station, Journal Paper No. 1045.

in the soil, although some individuals have been found at 4 to 6 inch depths in November and in March. The larvae fed through three summers and caused their most serious injury in the third summer. The movement of larvae in the soil, both vertical and horizontal, is not too well known, but is influenced by temperature, moisture and food supply. During periods of high temperature in July and August it was often necessary to dig down 12 to 18 inches in muck to find specimens. In dry seasons such as the fall of 1956 it was practically impossible to find a single individual in areas known to have a high population in the spring.

Populations in infested fields were variable, but were usually concentrated in low areas and around host plants. In corn fields more than one larvae per kernel was seldom found, but as kernels and plants were destroyed, the concentration around surviving plants became more intense. A single wireworm could cause the death of plants up to 20 to 24 inches in height and as stand was reduced as many as 25 have been found around the roots of a single plant. In one seriously infested field where only a few plants survived, a trench six inches wide and six inches deep down the corn row had an average population of 12 larvae per linear foot. Potato seed pieces in the spring were often found with 10 to 12 worms each, although sprouting was seldom affected. In one instance where the larvae were attacking germinating soybean seed, a handful of loose soil from the row contained 15 to 20 seed and a like number of wireworms.

The sampling of soils to determine wireworm populations proved to be laborious and not too enlightening. Baiting with ground whole wheat, ground corn and whole kernel corn also was not too successful. One example was a field where 12 lots of whole corn were placed around the field on April 19 and dug up on the 26th. From the 12 foot-square samples from the areas around the bait stations there were no wireworms in the top three inches, a total of 4 in the 3-6 inch level, 4 in the 6-9 inch level and 4 in the 9-12 inch level.

A field in Starke county was extensively surveyed in May by taking 4 square inch samples at numerous places in the muck portion. A metal frame was shoved into the soil and the material was removed in three inch layers and carefully examined. The average number of wireworms found per square foot was 1.36 in the 0-3 inch level, 0.89 in the 3-6 inch level and 0.52 in the 6-9 inch level, or a total of 2.77 per square foot 9 inches deep. Records of stand and yield from this field are given in Table 1 and suggest an apparent correlation with the wireworm population.

During the past five years wireworms have been collected in as many locations around the state as possible. The identification of the larval stage is quite difficult, as no good key for determining them is available. Some of the larvae collected have been preserved and others reared and both types of specimens sent to M. C. Lane, who has cooperated in supplying identifications. Eight species of larvae have been collected and identified and of these *Melanotus communis* (Gyll.), the

TABLE 1. The wireworm population of a field in the spring compared with the stand and yield of corn in the fall.

Location	Wireworms per square foot at different depths in inches				Per 100 feet of row			
					Plants		Ears	
	0-3	3-6	6-9	Total	killed	survived	harvest	weight
	No.	No.	No.	No.	No.	No.	No.	Pounds
A.	1.60	0.8	0.8	3.20	2.5	64.5	63.5	41.3
B.	1.80	0.67	0.45	2.92	5.0	68.5	58.0	30.0
C.	0.43	0.85	0.11	1.39	3.0	93.0	93.0	61.6
D.	1.62	1.26	0.72	3.60	14.0	60.5	59.5	36.0

corn wireworm, was the most abundant in numbers and in distribution. Soil types in which this and other species have been found, have shown some variation but usually have been consistent for any one species.

Melanotus communis (Gyll.) is a common pest of corn in the midwest and eastern parts of the country. It was collected in 31 fields in Starke county, four in Pulaski and one each in Jasper, DeKalb and Kosciusko counties. In general the predominant soil type has been a deep, black muck, although it also occurred in black sand and even a light sand. Losses have been serious in most fields where it occurred, but often the area of infestation was small. In muck this has been the predominant species and has caused damage to both corn and potatoes. Some damage to the latter crop was caused by larval feeding on the seed pieces, although the greater loss was caused by the pitting, and rarely the tunnelling, of mature tubers in late summer. Losses have run as high as 35 percent because of the discards in the grading. Some injury was also observed to onion bulbs and to the wheat used as a windbreak for onions.

Melanotus communis var. *A* of Dietrich is considered by Lane as a distinct species and was found on only one farm and that in Starke county. In this instance the soil in two fields was a deep, black "itch" muck. (Soils with the "itch" characteristic were both muck and sand and contained sharp particles of silica.) The 50 acres in the fields were planted with lindane treated seed, but by June 7 the insects had destroyed 90 percent of the stand. On the following three days the fields were planted again, this time with a row treatment of aldrin mixed in with the fertilizer. Of this second planting the wireworms took about 20 percent of the stand, although the stand of 80 plants per 100 feet of row at harvest gave a satisfactory yield.

Melanotus communis var. *B* of Dietrich is also considered by Lane as a distinct species and was found in four fields lying along the Kankakee river, two in LaPorte and two in Starke counties. This land, a part of the old Kankakee swamp and surrounded by ditches and dikes, is lower than the level of the river. The lower areas were flooded with 8 to 12 feet of water in June, 1950; September, 1954; and May, 1956.

Our attention was called to the area in LaPorte county in June, 1951, when wireworms destroyed 170 acres of corn on one farm. Twenty acres of this were replanted with lindane treated seed and produced a good crop, as counts of ears at harvest showed an average of 81 ears per 100 feet of row on the treated as against 12 on the untreated. In 1952 the loss in the 150 acre field was about 10 percent of the stand, while in 1954 serious losses occurred on three acres only. The soil type in the area is a sandy loam which often has an impervious layer of clay under it and sometimes quicksand under that. The upper soil has a high organic content and has been called an "itch muck" by some farmers. The land has a tendency to be wet and can be farmed only by the use of extensive drainage ditches and by pumps to lower the water level.

Melanotus blatchleyi Leng has been found only on a farm in Marshall county where the soil is a deep black muck. This infestation was found in 1951 on land being farmed for the first time. The damage was unusual, as the wireworms killed onions and the wheat windbreak in a circular area of about two acres. Corn in the adjacent rows was four to eight inches tall at the time, but was not harmed. The entire muck area was treated with a soil insecticide and the only specimens found two years later were in an untreated fence row.

Melanotus divarcarinus Blatchley has been found in Tippecanoe and Decatur counties. In both instances the soil has been a light colored loam and the crop was corn.

Melanotus fissilis (Say) was collected on four farms in Starke county, one in White and one in Jasper. In two instances it was found associated with *M. communis.* The soil types were quite variable and included a black prairie loam, light sand, and light changing to black sand with some muck. The crop attacked was corn except in one instance it was soybeans. Here the soybeans were planted in a light sand and the germinating seeds in four spots were attacked by the wireworms. Even here the stand would have been satisfactory except that moles tunnelled under the infested seed. The farmer estimated his loss at 33 percent of his stand, but actually it was less than one percent.

Agriotes mancus (Say) is known as the wheat wireworms and was found in Warren county in some newly drained brown muck or peat. Damage to corn and potatoes was observed.

Limonius dubitans LeConte is a widely distributed species with diverse food plants. It was collected from eight fields in Starke county, two in Jasper, two in Marion and one in Ripley in southern Indiana. This species was always found in sandy types of soil, ranging from the light to black sand. In some instances parts of infested fields were mixed with muck. The food plants include corn, potatoes, onions, cabbage, and several cucurbit seeds. In Marion county this insect was largely responsible for the discontinuance of potato raising, as a high percentage of the tubers were injured. We observed in some fields the soil full of beetle emergence holes and hundreds of beetles crawling on the soil surface or flying a few feet above the soil. In northern Indiana extensive areas of corn growing on poorly drained sand were damaged.

Summary

Eight species of wireworms have been collected and identified from Indiana, especially from Starke and other counties in the northern third of the state. All species attacked corn and most of them potatoes. Other crops attacked included onions, cabbage, soybeans, wheat and seeds of certain cucurbit crops. The commonest species was *Melanotus communis* (Gyll.), which showed a preference for muck soils, although it occurred in both light and black sand. *Limonius dubitans* LeConte showed a preference for sandy soils and had the largest number of host plants. Other species found and the soil type in which they were living were as follows: *M. communis* var. *A.* muck; *M. communis* var. *B.* sandy loam; *M. blatchleyi* muck; *M. divarcarinus* loam; *M. fissilis* muck, loam, sand; *Agriotes mancus* peat. All species collected were associated with poorly drained areas. Sampling the wireworm population in advance of planting proved to be laborious, but did suggest an apparent correlation between the early population and subsequent damage.

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A Separator for Sampling the Soil Fauna[1, 2]

JERRY M. MACKLIN[3] and B. ELWOOD MONTGOMERY, Purdue University

Occasionally it is desirable to sample as many of the insects found in a given soil as possible. Owing to the large number of extremely small insects encountered in the soil, a soil separator is almost indispensable. Several devices of different design have been used for this purpose. One of the more interesting is an ingenious device which was designed by Dr. George Salt (1952) for his studies on soil-inhabiting arthropods. Dr. Salt's theory and drawings were used as a guide in the design and operation of the equipment described here.

This particular soil separator was developed in an effort to secure a complete sample of the insects present in the soil of a clover field. To determine its effectiveness, the soil separator was compared with a device similar to the Berlese-Tullgren funnel described by A. H. Strickland (1947). A 40-watt bulb was used above the soil to dry it more slowly than the 60-watt bulb mentioned by Strickland. To compare the two devices, soil samples were divided in two equal parts. One-half was run through the soil separator and the other half was placed in the funnel. This test showed that the soil separator was more effective than the funnel, the ratio of the insects found being 6:1. It is probable that some insects still escaped detection in the separator, although precautions were taken to prevent this.

A. H. Strickland states that by using a 60-watt bulb suspended ten inches above the soil in a Berlese-Tullgren funnel for six days, all of the insects were driven out of the soil. Strickland's belief was based on the fact that, after being dried in the funnel, the soil was washed and examined with a hand lens, and no insects were found. It is not likely, however, that the insects were all driven from the soil. Ivar Tragardh (1933) suggests one explanation. He states that probably the smaller species die before they can escape from the soil. He also states that proper illumination and magnification are very important in determining the presence or absence of the smaller insects.

A diagram of the separating equipment used by the authors is shown by Plate A. The soil to be sifted is first moistened with water and then frozen. This breaks down the soil structure and makes it easier to run through the sieves. The soil may be held in the frozen state for a considerable length of time, if necessary, before it is sifted. The samples used by the authors were held in the frozen state for about twenty-four hours before being allowed to return to room temperature. After the sample is thawed it is placed on the first sieve, designated as

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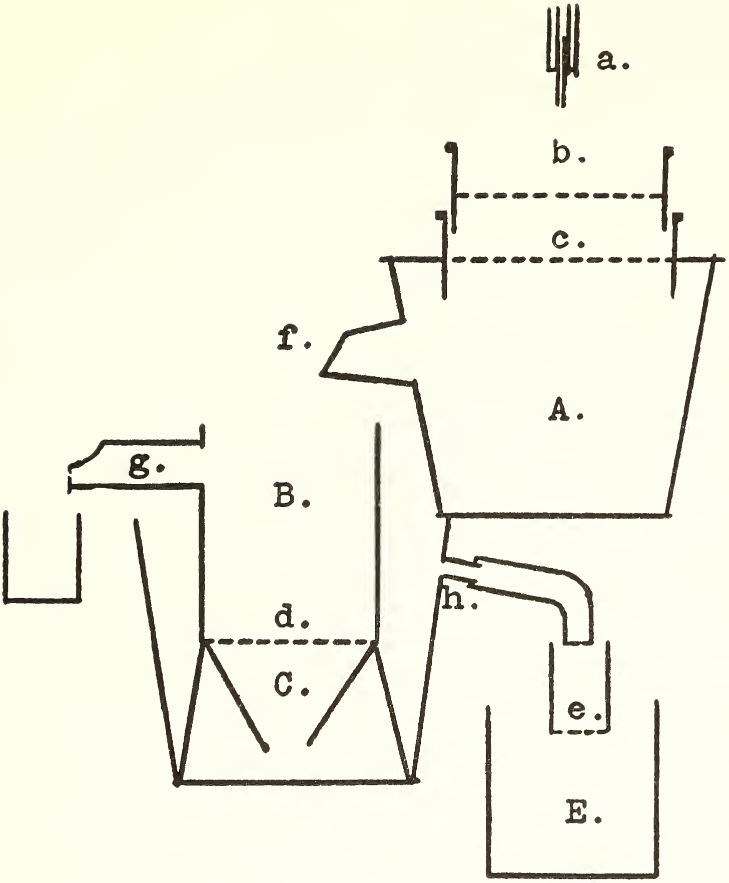
[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1046.

[2] This is part of a thesis submitted to Purdue University in partial fulfillment of the requirements for the degree of Master of Science.

[3] Present Address, Portland High School, Portland, Indiana.



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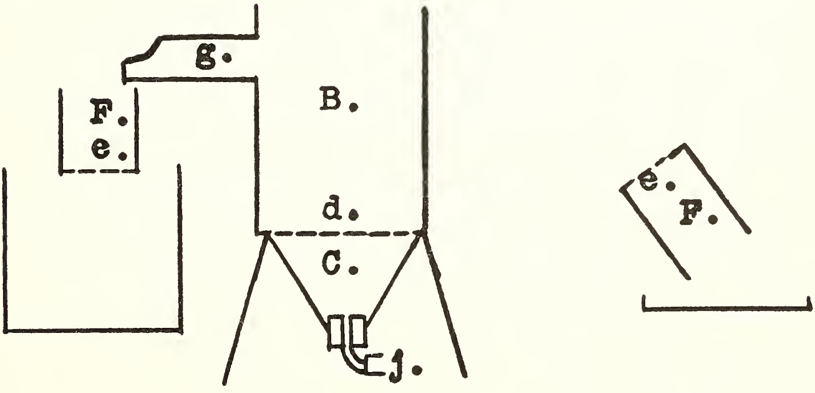

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Plate A. Diagram of Soil Separator.
Fig. 1. Entire apparatus in operating position.
Fig. 2. "Bubbling equipment" in operating position.
See accompanying text for explanation of parts and procedure.

b, Plate A. A jet of water is then played upon the soil causing it to break down into small particles. From here it is passed through the sieve *c* and into container A. These first two screens are standard soil sieves number 10 and number 30, respectively.

With the exception of the comparatively large specimens, such as cutworm larvae, most of the specimens are washed into container *B* which is suspended in water. At the bottom of container *B* is a .05 inch mesh bolting cloth sieve *d*. The water level is held above this sieve to prevent its becoming clogged with soil particles and root fragments. Any specimens which are small enough to pass through this sieve either flow out through spout *h* or settle to the bottom of the container. Because some of the specimens will fall to the bottom of the large sediment buckets, the contents of both must be sifted through a second bolting cloth sieve *e* of 0.1 inch mesh. Those specimens which are screened out on the second sieve are washed into petri dishes for inspection and determination.

For the specimens which are stopped on the .05 inch mesh sieve, however, a different technique is employed. Container *B* is especially designed with a detachable funnel *C* below the sieve. It is removable so that the cloth can be replaced when necessary. The funnel shape permits sealing it with a rubber stopper. By using a glass tube through the stopper, the bolting silk can be backwashed with a solution of magnesium sulphate. This solution, which is mixed to have a specific gravity of 1.2, causes the insects to float away from the root fragments more readily.

The bubbling equipment used to backwash the .05 inch mesh sieve is shown on Plate A. When container *B* is about three-fourths full of magnesium sulphate, air is bubbled through the tube *j*, causing the insects to float free from the root fragments and soil particles. This process is repeated a second time; then the level of the magnesium sulphate solution is raised until all of the specimens float through the spout *g* into cylinder *F* where they are caught on another .01 inch mesh sieve *e*. From this sieve the specimens are washed into petri dishes as before. A binocular microscope and a camel's hair brush are used for separating the specimens and transferring them into vials of preservative.

Table 1 shows the insects collected in six samples taken from a red clover field near Lafayette, Indiana, during the 1953 growing season. The samples were taken with a steel cylinder which removed a core of soil ten inches long and three inches in diameter. The first samples were divided into two inch sections for processing in an effort to determine whether or not the insects were more abundant near the surface. Little or no difference was found within the top ten inches in this particular field. Examination of a few deeper samples showed, however, that very few insects were present below the ten inch depth. This soil sampler, which was designed by Dr. A. R. Bertrand of the Agronomy department at Purdue University, is described in detail by Macklin (1956).

TABLE 1. Soil Insects Found in a Tippecanoe County Field.

Actual Number in Sample		Number Calculated per cu. ft.	
Sample I (IV-6-53)			
Thysanura	30	Thysanura	240
Collembola	350	Collembola	2,848
Coleoptera	1	Coleoptera	8
	387		3,096
Sample II (VI-23-53)			
Thysanura	13	Thysanura	317
Collembola	52	Collembola	1,369
	65		1,686
Sample III (VII-28-53)			
Thysanura	21	Thysanura	512
Collembola	9	Collembola	220
	30		732
Sample IV (VIII-13-53)			
Thysanura	8	Thysanura	195
Collembola	198	Collembola	4,831
Corrodentia	1	Corrodentia	24
Coleoptera	1	Coleoptera	24
Lepidoptera	7	Lepidoptera	171
Diptera	1	Diptera	24
Hymenoptera	60	Ants[1]	
Hymenoptera	183	Pupae[1]	
	459		5,269
Sample V (VIII-29-53)			
Collembola	145	Collembola	3,538
Coleoptera	1	Coleoptera	24
Lepidoptera	71	Lepidoptera	1,732
	217		5,294
Sample VI (IX-29-53)			
Thysanura	7	Thysanura	171
Collembola	187	Collembola	4,563
Lepidoptera	13	Lepidoptera	519
Hymenoptera	1	Hymenoptera	24
	208		5,277

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[1] Only the actual numbers of ants and pupae collected are shown, because they are not indicative of the number per cubic foot throughout the field.

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GEOLOGY AND GEOGRAPHY

Chairman: B. H. SCHOCKEL, Valparaiso University

THOMAS G. PERRY, Indiana University, was elected chairman for 1957

ABSTRACT

Recent Changes in Chalkland Agriculture. JOHN FRASER HART, Indiana University.—British agriculture has undergone striking changes over the last two decades. The most spectacular changes of all have occurred in the Chalkland country which stretches across the southeast and south of the island. The traditional system of sheep and barley farming has given way to extensive grain production with increased emphasis on both dairy and beef cattle. The changes are partly the result of wartime exigencies, partly a product of such technical innovations as the combine drill and the milking bail. Change has been facilitated by the large size of Chalkland farms. A potential problem is posed by extensive Service holdings in an area which formerly was not nearly so highly developed agriculturally.

Maintaining Lake Levels With Water From Wells. THEODORE KINGSBURY, Indiana Department of Conservation.—Practically every summer and fall there are periods during which the recharge into many of the lakes in Indiana is not sufficient to offset the losses. This results in declines in water levels with a number of serious detrimental effects. In small lakes and farm ponds it may mean a loss of supply for watering livestock or unhealthful stagnant water. In larger lakes it may result in a loss of fish life, a set back to recreational facilities and activities, and unhealthful conditions for property around the lake shore. In seeking a possible remedy for situations of this kind, interested organizations and individuals have presented their problems to the Division of Water Resources, State Department of Conservation and in most cases have asked about the feasibility of drilling wells and using water from them to maintain in some degree, at least, the normal lake level.

The Division has made several studies along this line, the most recent being at Cedar Lake. Records indicated there were several periods in excess of 100 days when the lake level was below the crest of the outlet dam. Eleven wells pumping steadily at the rate of 200 gallons a minute would raise the lake level only .012 of a foot a day or to or above the elevation of the crest of the dam for approximately two-thirds of the 104-day drought period of 1955. The cost of such a project would be at least $5,000 to drill and equip each well and about $1,000 to operate it during this more than three-month period.

The enormous water requirements, the lack of available pumpage data to assure continuous production and the cost of drilling and operation appear to make this project impractical. When an adequate supply of ground water is known to be obtainable from sources that do not draw from the natural recharge into the lake and when pumping costs can be reduced by relatively shallow wells, the plan may be feasible. On some small privately owned lakes and ponds the plan is now in use with apparent success. However, there is one phase of this type of project that should be taken into consideration. While there are at present no laws prohibiting the use of ground water for this purpose there is some sentiment against it which may lead to the enactment of regulating legislation.

A Rigorous Estimate of the Economic Importance of Indiana's Counties

B. H. SCHOCKEL, Valparaiso University

The objective of this project is measurement and portrayal of the economic importance of the counties of the United States—an experiment in areal differentiation, by which the counties are comparable percentage-wise. The intent is to test a technique for such measurement and portrayal. This article is limited to the counties of Indiana, as a sample, see Fig. 1.

In procedure the areal differentiation is achieved by portraying each county in terms of its percentage of a mythical Representative County of the United States used as a standard. Thereby the estimated relative importance of any counties of the United States can be noted, and in addition significant groupings of counties can be detected, in areal differentiation.

The area of the mythical Representative County is 675 square miles, the same being the average size of the counties of the states east of the Rocky Mountains. By mathematical proportion the values of the mythical county were deduced in the following items, total and per square mile: (1) population, (2) value of products sold from the farm, (3) value added by manufacturing, (4) wholesale sales, (5) retail sales, (6) persons employed in mining and quarrying, and (7) employed persons not involved in the items 2-6.

With these 14 norms of the Representative County used as a basis, each Indiana county's percentage of the Representative County was calculated for each of the 14 norms, and then 14 maps were drawn. Since the rating of the counties is in terms of percentage of the representative, the 14 ratings for each county were then integrated into one composite rating, namely its rating in economic importance. The final result therefore is one map of Indiana portraying the economic importance of its 92 counties, as of 1950, each comparable to all 3,072 counties.

The core of the formula is — $\dfrac{\text{county x 100}}{\text{Representative County}}$

Why 675 Square Miles?

A mythical county of 675 square miles as "representative" county advantages the use of the average county of the United States, and the median county thereof. Examination of a county map of the United States reveals huge counties in the Mountain States and the Pacific States whereas the counties of the states east of the Rocky Mountains are much smaller and, in addition, approach gross homogeneity in size. Areally these "eastern" counties represent the United States better than do the "westerns." Moreover the "easterns" far outweigh the

ECONOMIC IMPORTANCE
COUNTIES OF INDIANA, 1950

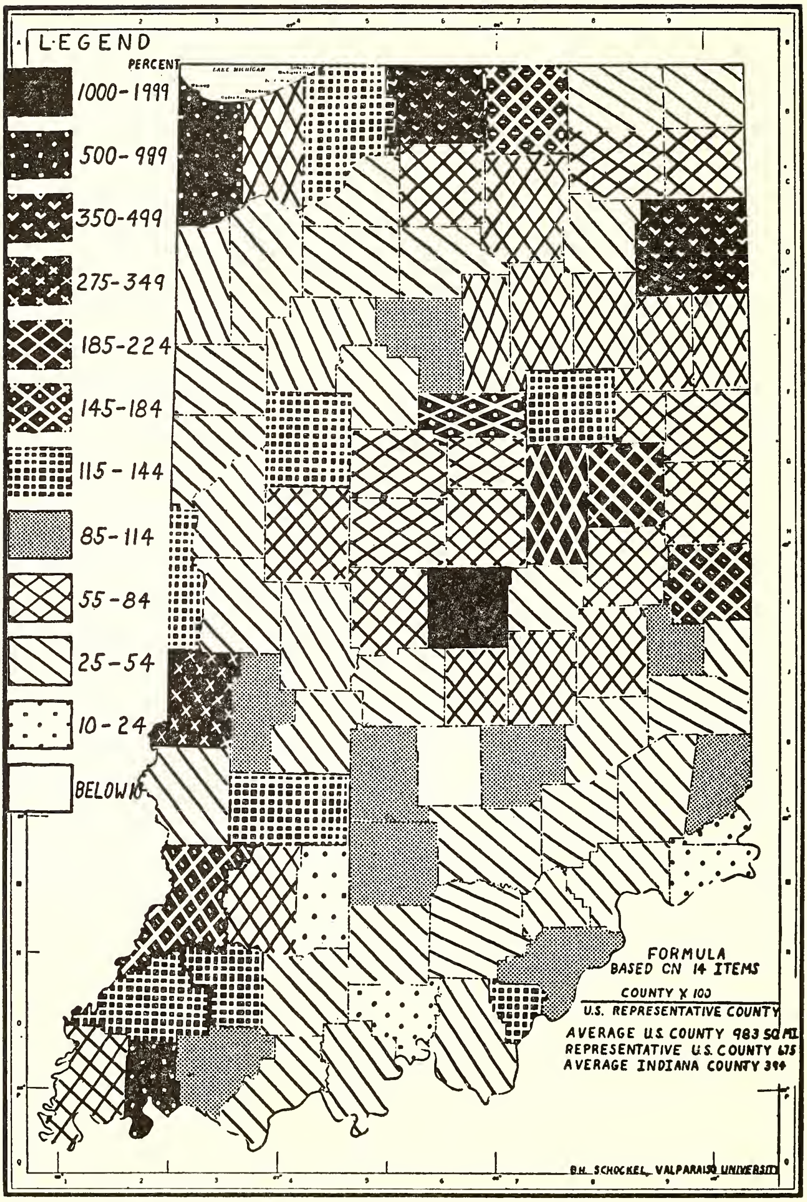
LEGEND
PERCENT
1000-1999
500-999
350-499
275-349
185-224
145-184
115-144
85-114
55-84
25-54
10-24
BELOW 10
FORMULA
BASED ON 14 ITEMS
COUNTY X 100
U.S. REPRESENTATIVE COUNTY
AVERAGE U.S. COUNTY 983 SQ MI.
REPRESENTATIVE U.S. COUNTY 675
AVERAGE INDIANA COUNTY 394
B.H. SCHOCKEL, VALPARAISO UNIVERSITY

Figure 1. The percentages are per cent of the Representative County of the United States, the area of which is 675 square miles. Gray, stippled counties approximate the Representative County in economic importance. The black counties, and white-on-black, denote superiority. The white counties, and black-on-white denote inferiority.

"westerns" in overall economic activity, and population. Hence the average area of the "easterns," some 675 square miles, is assumed to be representative, and thereby establishes the mythical Representative County.

The area of the average county of the United States, some 983 square miles, is too large to be representative. A portrayal based upon a county of 983 tends to depress the estimated overall economic importance of each county, although the importance of the counties to each other is substantially correct. (The average area of the counties of Indiana is only 394 square miles.) The area of the median county of our country is less than 675 square miles; it ranks about 175 counties below the Representative County. A portrayal based upon the median county tends to exaggerate the estimated overall economic importance of each county, although not the relative importance.

The area of the Representative County lies between that of the average and the median, somewhat larger than the latter and sharply smaller than the former. Finally, the Representative County is attuned to the specific uniqueness of the United States; it is not a conventional mean or median; probably it, as herein defined, could not be used for any other county. Admittedly this Representative County is not perfection; but it is an improvement.

Areal Importance

The basic items employed, namely 1-7, constitute a totality, a unity for areal treatment. The project is a study of areal importance only. For example, addition of the item, economic importance per person, would ruin the areal unity, by stressing competence per person instead of performance of area. Incidently item number 7, all other employed persons, constitutes about one-quarter of the total of the employed persons in Indiana, and therefore is too important to be ignored. For the sake of brevity the item has not been broken down into its components—into construction, transportation, business service, professional callings, etc.

Breakdown of Integrated Map

It will be helpful to break down the integrated map of Indiana, Fig. 1, into the items which have been integrated into it. This map of the estimated overall economic importance of the counties is an integration of 14 maps, each representing a component or norm. To save space, two token tables are presented instead of the 14 maps. (Tables 1, 2.)

An important item is agriculture, in the form of products sold from the farm, and measured in terms of percentage of the Representative County: (a) products of the total county sold from its farms; (b) products sold from the county's farms per square mile of the county; and (c) the integration, $\frac{\text{a plus b}}{2}$, shown in Table 1.

TABLE I

Agricultural Importance of Indiana Counties 1950[1,2]

	Per Cent[3]		Per Cent[3]		Per Cent[3]
1. Clinton	250	32. Adams	170	63. Washington	114
2. Rush	243	33. Henry	170	64. Porter	111
3. Benton	238	34. Hancock	167	65. Franklin	110
4. Kosciusko	231	35. Newton	165	66. Dubois	109
5. Boone	230	36. Whitley	163	67. Sullivan	108
6. Carroll	223	37. Fulton	162	68. Daviess	106
7. Elkhart	223	38. Noble	162	69. Clay	97
8. Montgomery	221	39. La Porte	160	70. Spencer	95
9. Howard	218	40. Marion	157	71. Jackson	94
10. Tipton	217	41. Starke	156	72. Ripley	92
11. Hendricks	216	42. Warren	155	73. Greene	88
12. White	215	43. Putnam	154	74. Harrison	87
13. Tippecanoe	210	44. Pulaski	154	75. Ohio	83
14. Hamilton	209	45. La Grange	151	76. Clark	83
15. Wayne	205	46. Saint Joseph	151	77. Jefferson	82
16. Jasper	204	47. Union	148	78. Switzerland	80
17. Madison	200	48. Fountain	146	79. Dearborn	77
18. Wabash	200	49. Lake	145	80. Floyd	75
19. Allen	199	50. Bartholomew	144	81. Warrick	70
20. Marshall	194	51. De Kalb	144	82. Pike	65
21. Cass	194	52. Fayette	135	83. Orange	63
22. Grant	192	53. Posey	132	84. Crawford	62
23. Decatur	187	54. Gibson	131	85. Jennings	59
24. Knox	185	55. Vermillion	130	86. Scott	56
25. Johnson	184	56. Parke	130	87. Lawrence	55
26. Shelby	183	57. Jay	130	88. Owen	51
27. Randolph	182	58. Steuben	127	89. Monroe	39
28. Delaware	178	59. Vanderburgh	119	90. Perry	36
29. Wells	176	60. Blackford	119	91. Martin	29
30. Huntington	174	61. Vigo	117	92. Brown	16
31. Miami	174	62. Morgan	116		

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[1] Calculated from data from the Bureau of the Census.

[2] Based on integration of products sold from the farm: total and per square mile.

[3] Percent of the Representative County of the U. S.

In category b, which is per square mile, the counties of Indiana make their best showing: some 14 counties approximate the importance of the Representative County; while eight counties rank lower, the lowest one rating 21 per cent; whereas the remaining 70 counties rank higher, the highest one rating 313 per cent. In category a, which is total county, the counties of Indiana make a poorer showing in agriculture because they are small in area (394 square miles): some

TABLE II

Economic Importance of Indiana Counties 1950[1,2]

	Per Cent[3]		Per Cent[3]		Per Cent[3]
1. Marion	1550	32. Huntington	77	63. Benton	50
2. Lake	801	33. Posey	76	64. Fountain	49
3. Vanderburgh	549	34. Wabash	75	65. Jasper	46
4. Saint Joseph	444	35. Miami	73	66. Fulton	45
5. Allen	358	36. Kosciusko	73	67. Steuben	45
6. Vigo	332	37. Montgomery	72	68. Morgan	45
7. Madison	218	38. Blackford	69	69. Parke	44
8. Delaware	212	40. Porter	68	70. Newton	44
9. Elkhart	178	41. Hamilton	67	71. Starke	42
10. Wayne	170	42. Marshall	67	72. Spencer	41
11. Howard	155	43. Adams	66	73. Jefferson	40
12. Knox	153	44. Boone	66	74. Pulaski	38
13. Grant	139	45. Johnson	65	75. Sullivan	38
14. Floyd	139	46. Rush	65	76. La Grange	37
15. La Porte	134	47. Randolph	65	77. Perry	37
16. Tippecanoe	130	48. Daviess	63	78. Ripley	37
17. Pike	129	49. De Kalb	60	79. Orange	34
18. Vermillion	127	50. Noble	58	80. Union	34
19. Gibson	120	51. Tipton	57	81. Washington	32
20. Greene	116	52. Wells	55	82. Warren	32
21. Dearborn	114	53. Jay	55	83. Scott	31
22. Monroe	114	54. Hendricks	54	84. Owen	30
23. Clay	109	55. Carroll	54	85. Harrison	29
24. Fayette	102	56. White	54	86. Franklin	29
25. Clarke	101	57. Decatur	53	87. Ohio	27
26. Cass	93	58. Dubois	53	88. Jennings	25
27. Warrick	93	59. Whitley	51	89. Crawford	24
28. Bartholomew	86	60. Hancock	51	90. Switzerland	23
29. Lawrence	86	61. Putnam	50	91. Martin	19
30. Henry	81	62. Jackson	49	92. Brown	8
31. Clinton	78				

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[1] Calculated from data from the Bureau of the Census.

[2] Based upon the integration of 14 economic items.

[3] Percent of the Representative County of the U. S.

20 counties approximate the representative; while 30 rank lower, the lowest being 10 per cent; whereas 42 rank higher, the highest one rating 205. Finally in category c, which is integrated agricultural importance, the counties make a fairly good showing, as shown in Table 1, the highest one rating 250 and the lowest one 16.

In each of the other integrated items, the counties of Indiana make a poorer showing than in agriculture, as is indicated in Tables 1, 2. Space herein does not permit a token breakdown like the preceding one presented for agriculture. Suffice to say that above 100 per cent of the Representative County are 68 counties in agriculture; 20 in manufacturing and in population; 19 in retail sales; 13 in the item, "all other" employment, and in the item, mining and quarrying; and 6 in wholesale sales. As of 1950, Lake County leads in manufactural importance (although Indianapolis outrates Gary); and Vigo in mining importance; but Marion County leads in all other items.

In summary, it is these 7 items, per county totals and per square mile of the county, which are integrated as 14 norms to produce the map, Figure 1.

Consider the Map and Table II

The map and Table II depict the overall economic importance of Indiana's counties areally and statistically. According to Table II, some 25 counties rate higher than 100 per cent of the Representative County. Marion County heads with 1,550 per cent and Brown tails with 8.

On the map, the 92 counties are classified into 12 classes. The gray stippling denotes the class, 85-114 per cent, of which class there are 9 counties. They approximate the Representative County and could be assigned a grade of C. The devices, black, and white-on-black, indicate the classes above 114 per cent, of which classes there are 20 counties. (So ultra great is the economic importance of New York, Cook, and Los Angeles counties, etc., that there are no A counties in Indiana.) The devices, white, and black-on-white, designate the classes below 85 per cent, of which there are 63 counties. They comprise the D and the E counties. The highest county is about two hundred times the lowest county in overall economic importance.

The patterns portrayed by the map are significant and warrant brief description as follows:

Aside from the tremendous and embarrassing contrast between Marion and Brown, is the fact that six scattered spots spearhead the state. The nucleus of each spot is a large city, which dominates its service-area, affects a wider zone, and penetrates even farther through ribbons of conveyance-contact.

Areally approximately two-thirds of the state appears to be sub-par. There is a discontinuous lens of high importance, mostly B land, with an axis from Vanderburgh to Allen, via Marion; and there is a northwestern rich fringe. Also there is an axis of sub-par, D and E, land (much of it hilly) trending from Union to Spencer. And a crescent D area with tips at Fulton and Brown, widest in the sandy and erstwhile marshy land associated with the Kankakee River—a land which impeded north-south conveyance and thereby imprinted overall mediocracy to this day.

The Chicago-Lake Michigan fringe, axial with Fort Wayne, New York, Montreal and Detroit, is more flourishing than the Ohio River fringe.

There is a central core, dominated by Marion, Madison and Delaware, of rich glacial plains, supplemented historically by natural gas. This core is in effect surrounded by a sub-par ring. Incidently Marion, favored politically and now economically powerful, towers above a smaller ring with natural resources comparing favorably with those of the giant. (This quasi-restrictive dominance highlights the retail and wholesale maps.)

Coal, beverages, and longtime Ohio River bridgements pinpoint certain spots of affluence.

A geologist would note a pattern associated with the mineralized flanks of the axial anticline trending northwest from Cincinnati.

The circumstances of the economic patterns, and the patternal implications are too formidable for treatment herein.

Remarks

Indiana's counties do not fare as well by this measurement as by less rigorous estimates. It may be argued that the 675 square mile area of the Representative County acts as a depressent. It could be argued in rebuttal that the orthodox estimates have been too liberal, influenced by the high standing of the counties in agriculture, and by unconscious overlooking of the stupendous economic importance of the leading dozen counties of our country, which cannot be ignored in calculating the Representative County whatsoever its area. Moreover, even if the 92 counties have been rated rather low herein (?), the rated importance relative to one another and to the 3,072 counties is true since the measurement is uniform. Completion of the measurement of the 3,072 will prove to be illuminating.

By way of precaution it is stated that Indiana's economic importance is not 1/92nd of the sum of the percentages exhibited by the 92, i.e., it is not 107 per cent. As a state, Indiana should be rated in terms of the United States or in terms of a calculated Representative State. Nor does the map portray level of living of inhabitants.

The favorable rating of a group of counties in southwestern Indiana herein is a bit of a surprise. It is true that many Hoosier writers have been prone to depress the real importance of this southwestern area, known as the "pocket." Regardless, is the area as important as it is rated herein? Is the rating as of 1950 true in the light of the fact that since 1950 the net migration has been outward? The item, mining and quarrying, must be considered. This portion of the state leads in that item. Inclusion of the item tends to lower a bit the rating of many of the 92 counties. In rebuttal it is stated that multiplicity of developed natural resources is in fact important in the overall economic importance of a county. Incidently the problem of weighting the seven basic items in this measurement has not been solved.

A serious defect in the measurement for the map is as follows: The item, manufacturing, is in terms of value added in the process of manufacturing (manufacturing increment). But the item, retailing, is in terms of gross sales (not retailing increment); and likewise the item, wholesaling. The item, products sold from the farm, is not wholly satisfactory for use in the measurement.

It is assumed that the rating herein of the 92 counties will be useful. (Newspapers already have taken note because any serious rating is "news" to American readers.) An example in planning will suffice: Indiana and Uncle Sam contemplate spending billions on Indiana's highways. Recommendations as to location of such improvements have super-stressed the item, traffic flow. In effect this means that to those portions of the state which have should be given, with all Hoosiers participating in the cost. Which causes the geographer-planner to pause and to mull in the light of the patterns exhibited by the map. Is not the incidence of general welfare vital?

A Comparative Study of Rural Level-of-Living Indexes in Indiana Counties

ROBERT R. DRUMMOND, Indiana State College

Regional differences within Indiana have long been the subject of considerable interest. This paper is concerned with the contrast which now exist in the rural areas of the state. The object is to determine whether county differences in standard of living are still closely bound to the natural productivity of the soil, or whether the growth of Indiana's cities has produced conditions and demands for specialized agricultural crops which may have resulted in an increased level-of-living for agricultural families in counties with large urban populations.

The Federal Census item "Farm-Operator Family Level-of-Living Index" can be helpful in measuring the basic differences between geographical areas. The four components on which this index is based include: 1) percentage of farms with electricity; 2) percentage of farms with telephones; 3) percentage of farms with automobiles; and 4) average value of products sold or traded in the year preceding the census per farm reporting (adjusted for changes in purchasing power of the farmer's dollar). These indexes do not represent a particular standard; they indicate only the county level expressed as a percentage of the average of all counties in the United States.

The average index value for Indiana in 1950 (based upon the value 100 for the United States as a whole for 1945) was 149. The indexes for 1950 ranged from a minimum of 91 for Scott County to a maximum of 188 for Benton County. When the values for the state's counties are suitably grouped, and this information is reproduced on a map of Indiana, certain geographical contrasts are readily apparent (Fig. 1).

Sixteen counties with values comprising the entire two highest categories are located in the central and northern part of the state. In fact, all but one of the counties with indexes above the central grouping of values (141-160) are north of the southern limit of the Wisconsin glaciation ("1" in Fig. 1). This single exception is Vanderburgh County on the Ohio River, whose value is 161.

The twenty-five counties comprising the three lowest categories are located in the southern half of the state, with the two exceptions of Starke and Lagrange, which are in the extreme northern portion of the state. Furthermore, the twenty-three southern counties are all or mostly south of the southern limits of Wisconsin glaciation. Eight of the ten lowest counties are south of the Illinoian glaciation limits ("2" in Fig. 2).

The counties having level-of-living values within the central grouping (141-160) are scattered throughout the limits of Indiana. However, only four are either entirely or mostly within the non-glaciated area.

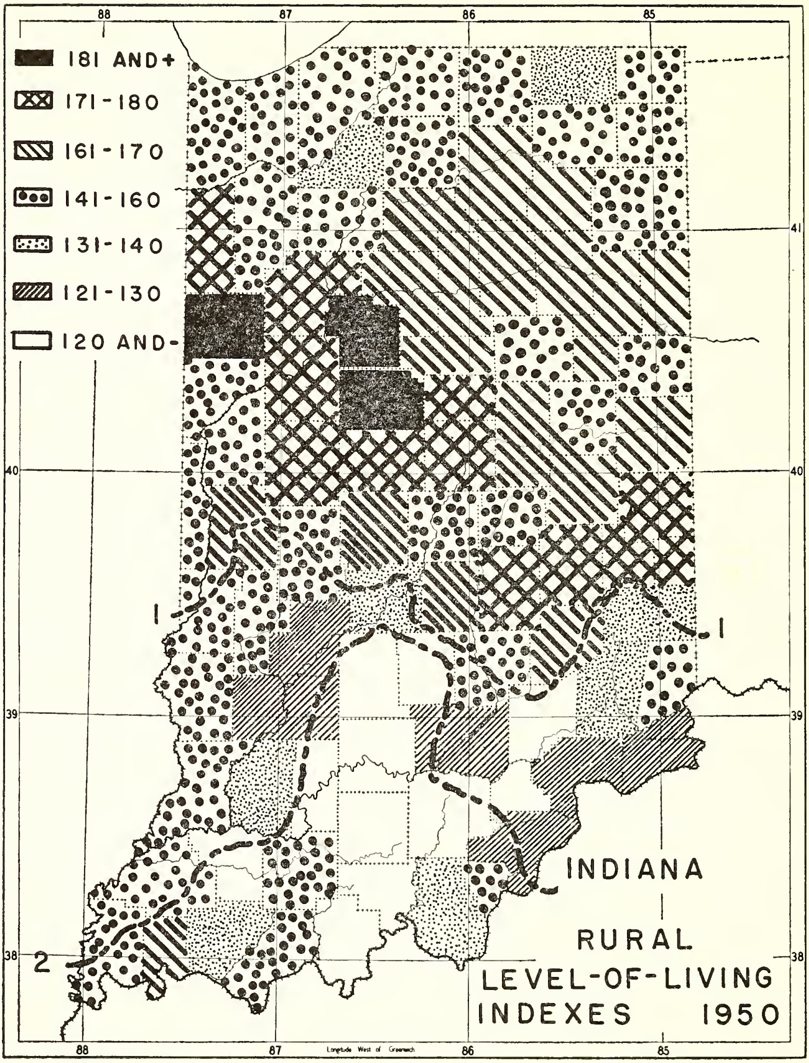

Figure 1.

In fact, only seven are within the area covered by Illinoian glaciation. Eight of these counties form a solid tier along the Wabash River in the southerly part of its course. Another continuous tier lies generally along the northern border of the state.

When examination is made of the level-of-living values for counties containing large cities, certain conclusions can be drawn. Nine counties in Indiana comprise all or part of eight Standard Metropolitan Districts.

These include Lake County (part of the Chicago Metropolitan Area); St. Joseph County (South Bend); Allen County (Fort Wayne); Delaware County (Muncie); Marion County (Indianapolis); Vigo County (Terre Haute); Vanderburgh County (Evansville); and Floyd and Clark counties (part of the Louisville Metropolitan Area). The seven Metropolitan Areas within the northern and central part of the state are comprised of counties which have rural level-living indexes which are lower than or no more than equal to their surrounding counties. In the case of Marion County (Indianapolis), six of the neighboring counties have indexes which have substantially greater values. Vanderburgh County and Floyd and Clark counties do have bordering counties which have rural level-of-living indexes somewhat below that of their own.

To summarize:

1). The counties with the lowest level-of-living values are generally within the non-glaciated area of Indiana.

2). The counties with the highest level-of-living indexes are all within the central portion of Indiana's area of Wisconsin glaciation.

3). The counties wholly or largely within the Illinoian glaciated area have level-of-living indexes well below those of the Wisconsin glaciation but decidedly above those of the non-glaciated counties.

4). The presence of cities either large or small appears to have little influence upon the rural level-of-living index. The possible exception to this observation includes both Evansville in Vanderburgh County and Floyd and Clark counties, which comprise a portion of the Louisville Metropolitan Area.

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Woodlands in Monroe County, Indiana

BARBARA ZAKRZEWSKA, Indiana University

Forests are an important natural resource of Indiana. They add over ten million dollars to the yearly income of the state's inhabitants. They offer employment to about 26,000 workers who earn over 61 million dollars working in the wood-using industries. They are especially important in southern Indiana which contains two-thirds of the state's commercial forest land (Fig. 1). In the north and center only the morainal hills have more than 10% of their land in forest. In the south, however, one-third of the unglaciated uplands is commercial forest land (1).

An area coinciding with the Crawford and Norman Uplands comprises the most heavily wooded belt of southern Indiana. Monroe County was chosen as a typical unit for the study of the woodlands of the southern part of the state. The county has 48% of its land in commercial forest, and contains sizeable portions of the two physiographic provinces which seem to be responsible for most of southern Indiana's woodland. Of the county's total area of 264,000 acres, 127,000 are wooded (4) and of this 52,592 are farm woodland, half of which is pastured. The total income from farm woodland for 1949 was $22,022.00 (2).

Relation of the Distribution of Woodlands to the Physiographic Provinces of Monroe County

The map of Monroe County woodlands (Fig. 2) reveals three distinct patterns of distribution. The eastern part of the county is very heavily wooded. The large areas of woodland are cut up only by long, narrow valleys of clear land.

The central part of the county shows a very small amount of woodland, some of it along the few surface streams, and a few patches of poor woods representing overgrown quarries.

The south-western part of the county has a very patchy type of forest cover in striking contrast to the more solid woodland pattern of the eastern part of the county.

A closer analysis of these patterns reveals some relationship between forest distribution and the physical characteristics of the three physiographic provinces.

The Norman Upland is a maturely dissected cuesta underlain by gently dipping sandstones and shales of the Borden group of Mississippian rocks (5). The two main characteristics of this upland are its great local relief and the uniformity of its topography. The upland is marked by very sharp ridges, deep narrow valleys, perfectly symmetrical drainage pattern, uniformly steep slopes, and uniform lithology (6). This topography is reflected in the woodland distribution of this

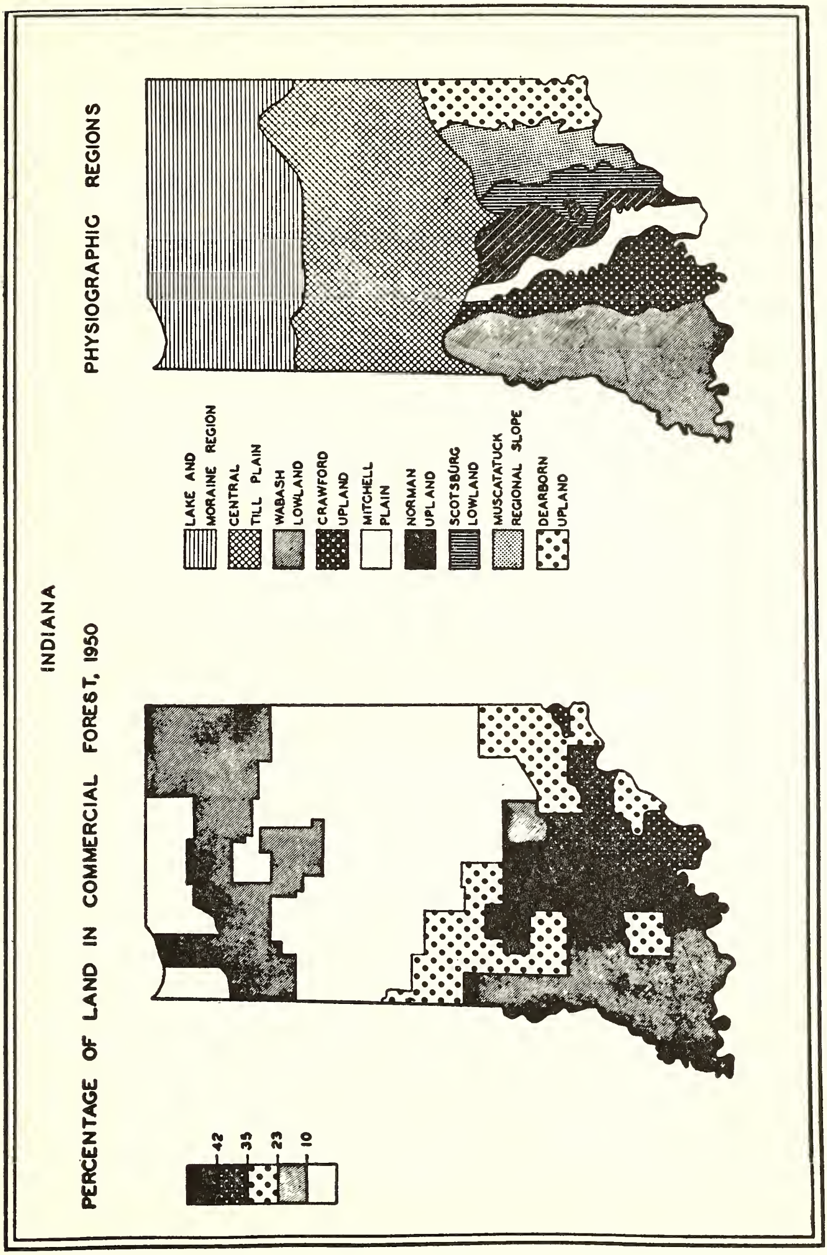
INDIANA
PERCENTAGE OF LAND IN COMMERCIAL FOREST, 1950
42
35
23
10
PHYSIOGRAPHIC REGIONS
LAKE AND MORAINE REGION
CENTRAL TILL PLAIN
WABASH LOWLAND
CRAWFORD UPLAND
MITCHELL PLAIN
NORMAN UPLAND
SCOTSBURG LOWLAND
MUSCATATUCK REGIONAL SLOPE
DEARBORN UPLAND

Figure 1

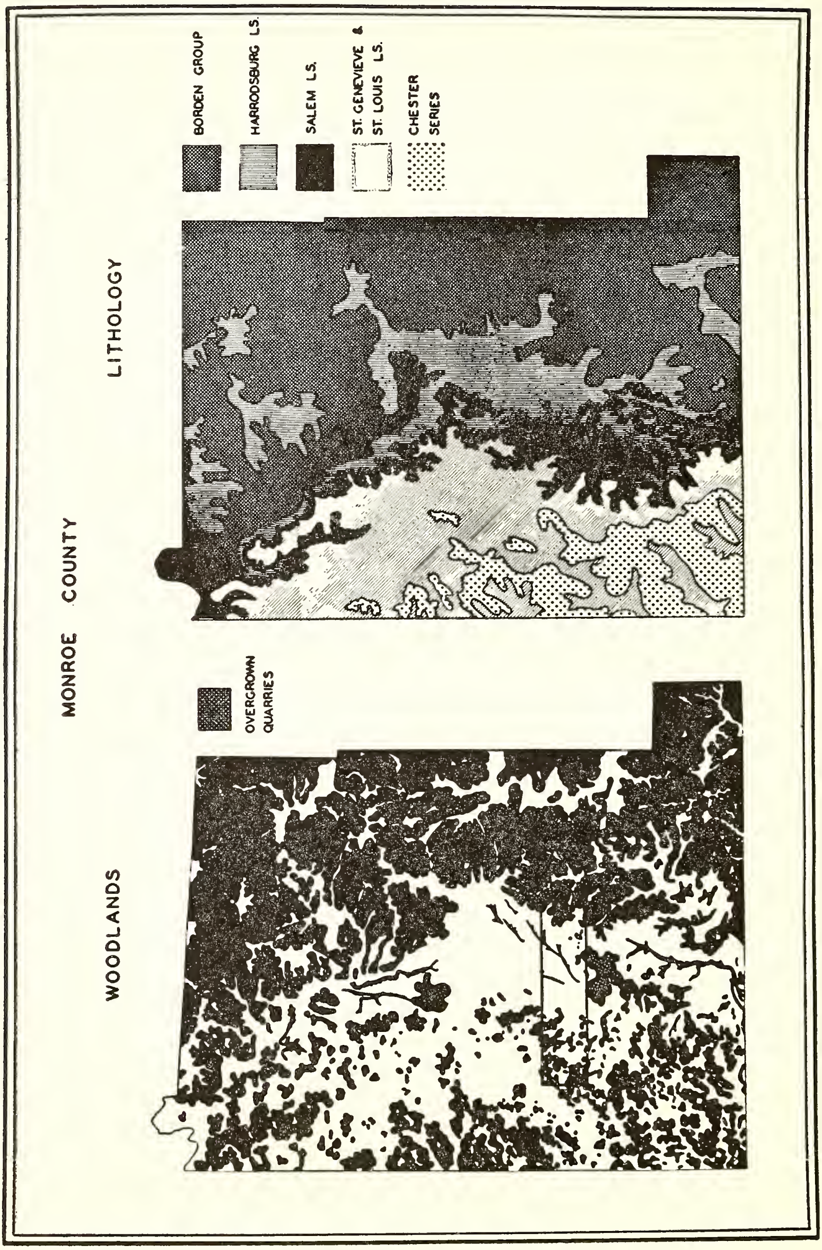
MONROE COUNTY
LITHOLOGY
BORDEN GROUP
HARRODSBURG LS.
SALEM LS.
ST. GENEVIEVE & ST. LOUIS LS.
CHESTER SERIES
WOODLANDS
OVERGROWN QUARRIES

Figure 2

part of the county. The monotonous forest cover is marked by uniformity of type and distribution.

The western boundary of the Norman Upland cannot be traced as a straight line. The Borden rocks dip under the limestones of the Mitchell Plain but not along a definite line (3). Ridges with Norman Upland characteristics extend deep into the plain, and limestone valleys characteristic for the plain reach in long tongues into the upland.

The poorly defined boundary between these two provinces shows as such on the woodland map. The long forest-free valleys represent Mitchell Plain limestones which do not support heavy woodland.

The Mitchell Plain is a dip slope area underlain by Harrodsburg, St. Louis, and St. Genevieve Mississippian limestones. This westward sloping plain is characterized by low local relief and karst topography.

In Monroe County the Mitchell Plain is narrow and very irregular. Nevertheless, on the woodland map the plain stands out as a distinct area generally devoid of trees except in the glaciated north-west corner, along the surface streams, and in the areas of abandoned quarries.

The western boundary of the Mitchell Plain is a zone of transition from limestone sinkhole plain to a highly and irregularly dissected upland of clastic rocks, rising to a considerable altitude. Extension of the plain features into the plain, in the form of outliers, makes it very difficult to trace the boundary between the plain and the upland to the east of it.

The Crawford Upland is an area of the Chester series of Mississippian rocks and some Mansfield (Pennsylvanian) sandstones. Erosion of alternating non-resistant shales and limestones, and resistant sandstones created the rugged, irregular, angular topography, with considerable local relief. The most characteristic feature of this upland, in contrast to Norman Upland, is the extreme diversity of topographic features and relief. The valleys, hills, and ridges, vary greatly in size and shape (6).

This sort of topography creates strikingly different pattern of woodland distribution. The patchy pattern developed here mirrors the irregular distribution of physical features of the upland. The woodlands coincide closely with the sandstone-capped hills; the wide, irregular valleys around them are clear of forest.

Detailed Examination of These Relationships as a Result of Field Mapping

This study was conducted by a group of students from Indiana University[1] in connection with a seminar on land utilization taught by Dr. J. Fraser Hart. An east-west strip about half mile wide running across the county was chosen as a study area. The choice was made in such a way as to include a part of each physiographic province represented in the county, with the exception of the glaciated north-west corner, which is not typical physiographic region for the heavily wooded part of the state. The mapping key included two types of forests: the better forest with trees of a diameter over six inches, and the poorer forest with trees of a diameter below six inches. Aerial photographs were used as base maps.

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[1] A. Lal from Pakistan, P. Karan from India, R. Krueger from Canada, R. Joppa from Minnesota, R. Perera from Ceylon, and B. Zakrzewska from Poland.

Examination of this narrow strip traversing three physiographic provinces reveals that the details of woodland distribution are primarily attributable to differences in bedrock which produce differences in slopes, dissection, and drainage in the three provinces. In addition to this, the study of the small area shows the types of forest which are associated with certain physical features of the provinces.

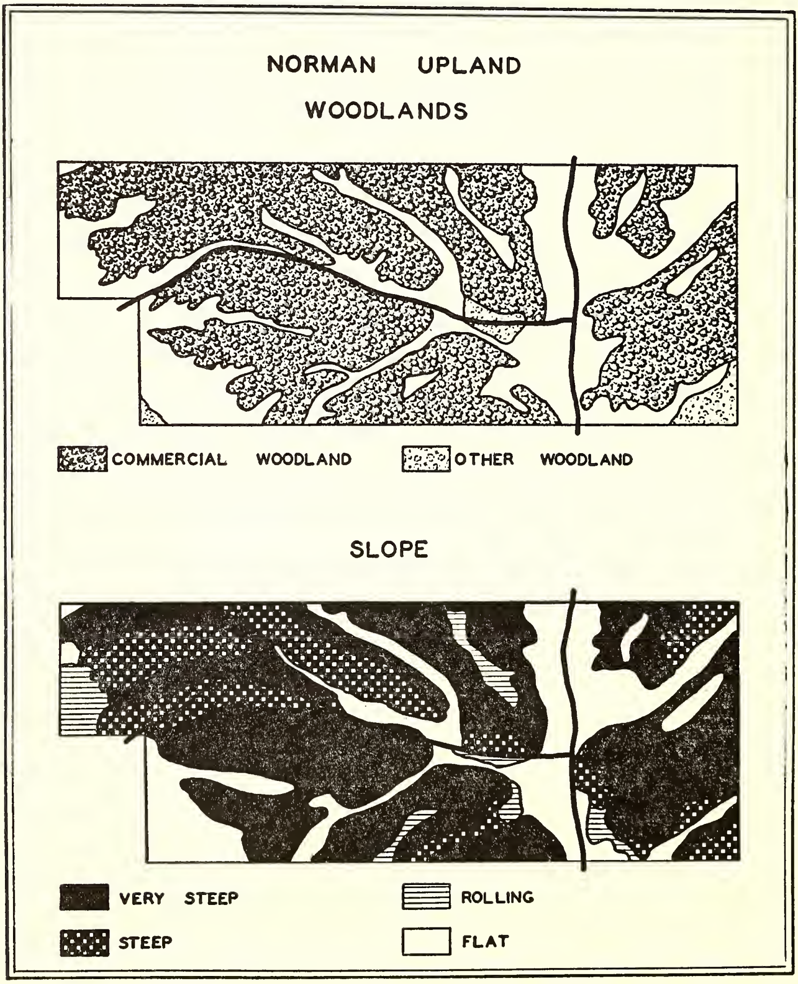

Figure 3

The Norman Upland strip (Fig. 3) reveals uniform, dense forest cover with limited clear land in the valleys and on level hilltops. Better forest is found on steeper slopes with thin soil, unsuited for agriculture, which have apparently never been cleared. Poorer forest, if found at all, is on gentler slopes once cleared but now abandoned for agricultural purposes. The flat hilltops are obviously abandoned lands and are now used for pasture or covered with thorny brush. The western edge of the woodlands shows the distinct difference between the heavy woodland of the Norman Upland and the woodless Mitchell Plain.

The Crawford Upland strip (Fig. 4) shows the patchy type of forest distribution, from both locational and qualitative point of view.

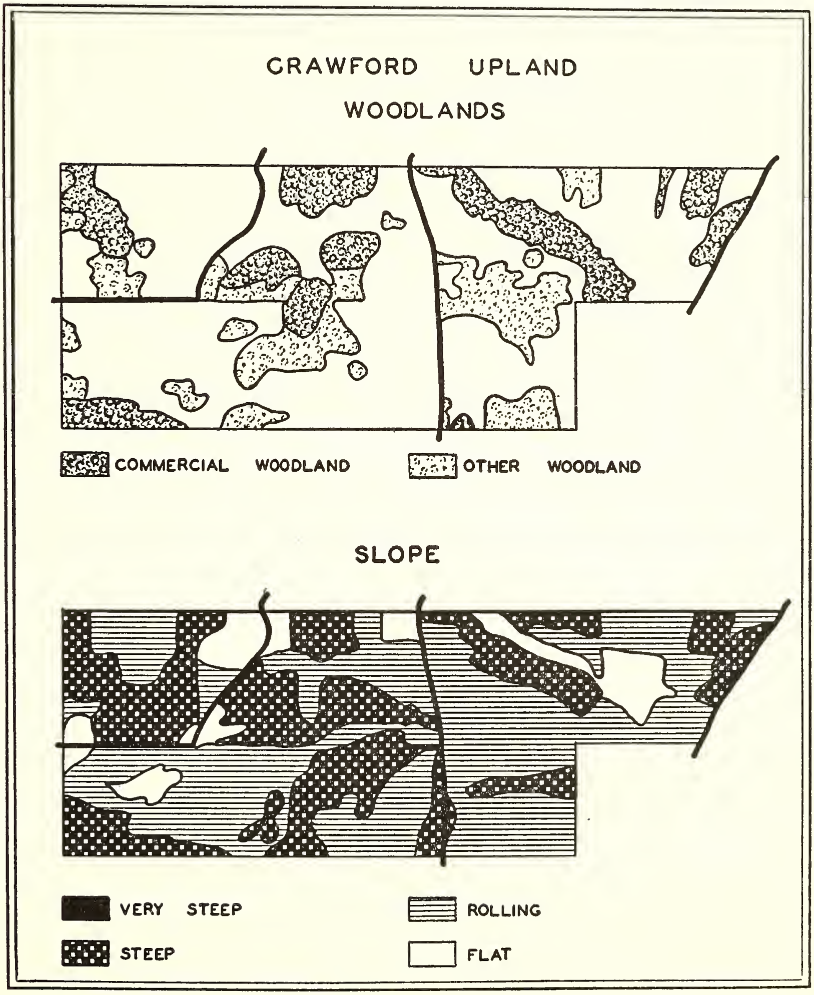

Figure 4

There are wider valleys and gentler slopes here; as a result, more land has been used agriculturally than in the Norman Upland. More land has also been abandoned and has grown into a poor type of forest.

The Mitchell Plain strip (Fig. 5) shows very little woodland. The elongated woodland strip represents trees along streams. The poor type of forest in the north-west corner of the strip covers a piece of land between a railroad and a highway which is not economically suitable for any other use except tree growth. The patch in the middle is an overgrown quarry. The poor forest in the south-east corner is a wooded sinkhole. The Mitchell Plain is still used agriculturally and there is little abandoned land here. The only forest worth mentioning

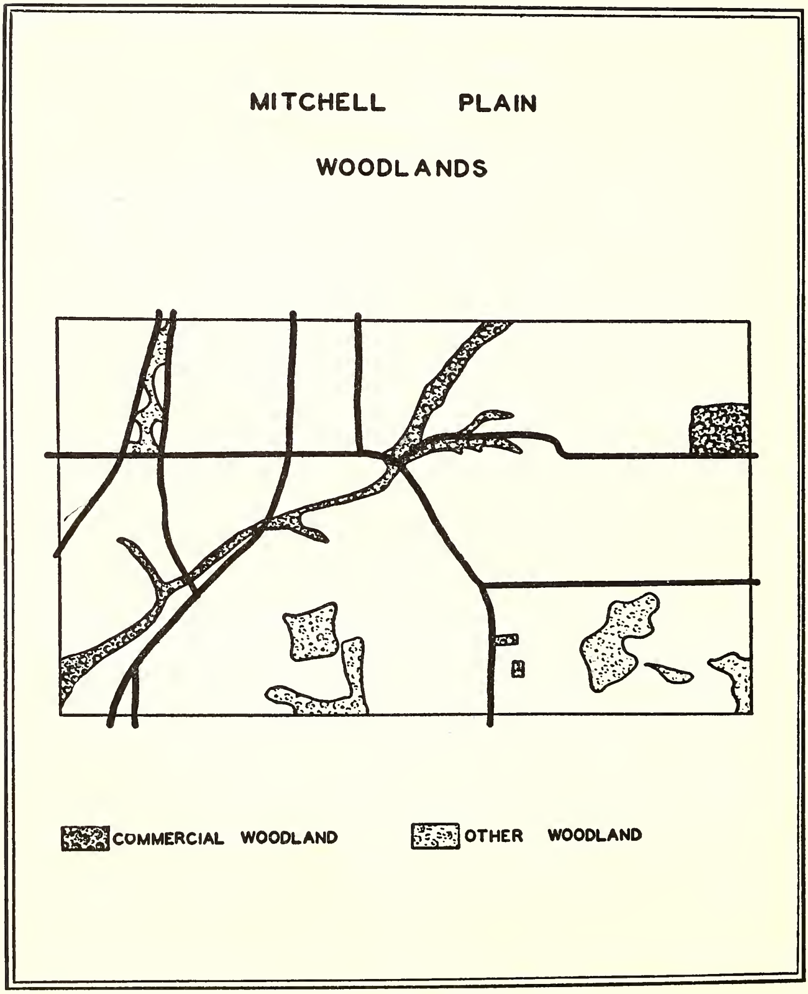

Figure 5

for its quality is the extension of the Norman Upland forest and the two small plots reforested by forest-conscious farmers.

Two conclusions can now be drawn from the above information: first, the county study reveals the close relation between the woodlands and the lithology and topography of the area; second, the study of the small area leads one to believe that the forest distribution is also a result of the history of land use.

The Future of Monroe County Woodlands

While this study was conducted, some observations were made concerning the quality of the forests and their utilization.

Most of the woodlands of this area are second growth forest in the state of wilderness and neglect. The woods are full of dead logs and branches and are generally understocked, especially in saw timber. Many trees are thin, dwarfed, distorted, or no more than shrubs.

Of the three areas studied the Norman Upland has the best forest. Here there is some material of commercial value, even though the forests consist of a great number of species with poor quality trees. There seems to be no selective cutting or proper management which would lead to better growth.

Grazing is practiced in the forests of both the Crawford and Norman Uplands. These upland woodlands show much erosion which is probably due to the destruction of underbrush by cattle. In contrast to this, the relatively scarce Mitchell Plain woodlands are generally protected by fences and seldom grazed.

Only one instance of logging operations was found in the study area. In Norman Upland there was a farm which had some simple equipment for handling logs. In the nearby woods, several fallen trees were found, but there was no sign of any extensive operation. Woodlands here seem to be the additional means of subsistence for the inhabitants of the hill who are unable to draw income from the limited land available for cultivation.

There is no proper management of Monroe County woodlands. The southern uplands' topography indicates that forests are the best land use for this area. Wise forest management, however, is imperative. Ninety-five percent of the forest in the state is privately owned, and three-fourths is in the hands of small farmers (1). It is, therefore, up to the small farmers to understand the problem and handle it properly.

The state can do its part by buying the forested areas, converting them into recreational parks and wild life reservations, and providing proper care for state owned woodlands. This would give the forests the necessary chance to recover from the human destruction which has devastated them so thoroughly in the last sixty years.

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The Clay Minerals in Some Glacial Lacustrine Sediments of Indiana[1]

JOHN M. SMITH and HAYDN H. MURRAY, Indiana Geological Survey

Introduction

During the Pleistocene epoch many areas in Indiana were sites of glacial lakes. The glacio-lacustrine deposits are of two origins. According to Thornbury (9, 10) a system of ice-marginal lakes resulted from the ponding of southwestern drainage by the lobe of Illinoian ice that extended into southwestern Indiana. A second system of lakes, Wisconsin in age, was formed south of the Shelbyville moraine owing to ponding of tributary valleys by extensive valley trains along streams carrying large amounts of outwash from the Wisconsin ice.

Lacustrine deposits are composed mainly of calcareous silts and clays. Some deposits, depending on their location within the lake boundary, contain sand and gravel. Many deposits are laminated or varved and may contain calcareous concretions .Well records indicate that lacustrine deposits may be as much as 150 feet thick in some areas (1).

The primary purpose of this investigation was to determine the clay mineral content in some of the lacustrine deposits. No previous study has been made of any clay minerals in the Pleistocene lacustrine deposits of Indiana. Measurements of pH were made, size analyses by the hydrometer method were obtained, and minerals other than the clay minerals were identified by means of X-ray diffraction and the petrographic microscope.

Samples for this study were collected from the following counties in Indiana: Allen, Sullivan, Owen, Monroe, Gibson, Pike, Perry, and Franklin (Fig. 1). Sample sites were selected by considering the age of the section, the degree of weathering, and the geographic location. Lacustrine sediments of both Illinoian and Wisconsin age were collected. A 5-pound representative sample was obtained from each lithologic unit by means of the channel sample method. A total of 28 samples was collected from 9 locations in Indiana.

Methods of Investigation

Samples were prepared for analysis by drying them for 24 hours at 60° C.; after they had been dried the samples were disaggregated in cloth bags with a wooden mallet. Care was exercised to ensure that only aggregates were broken and actual particle size was not reduced. A few tough aggregates which resisted disaggregation by the above method were broken down by use of a mortar and rubber pestle.

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[1] Published by permission of the State Geologist, Indiana Department of Conservation, Geological Survey, Bloomington, Ind.

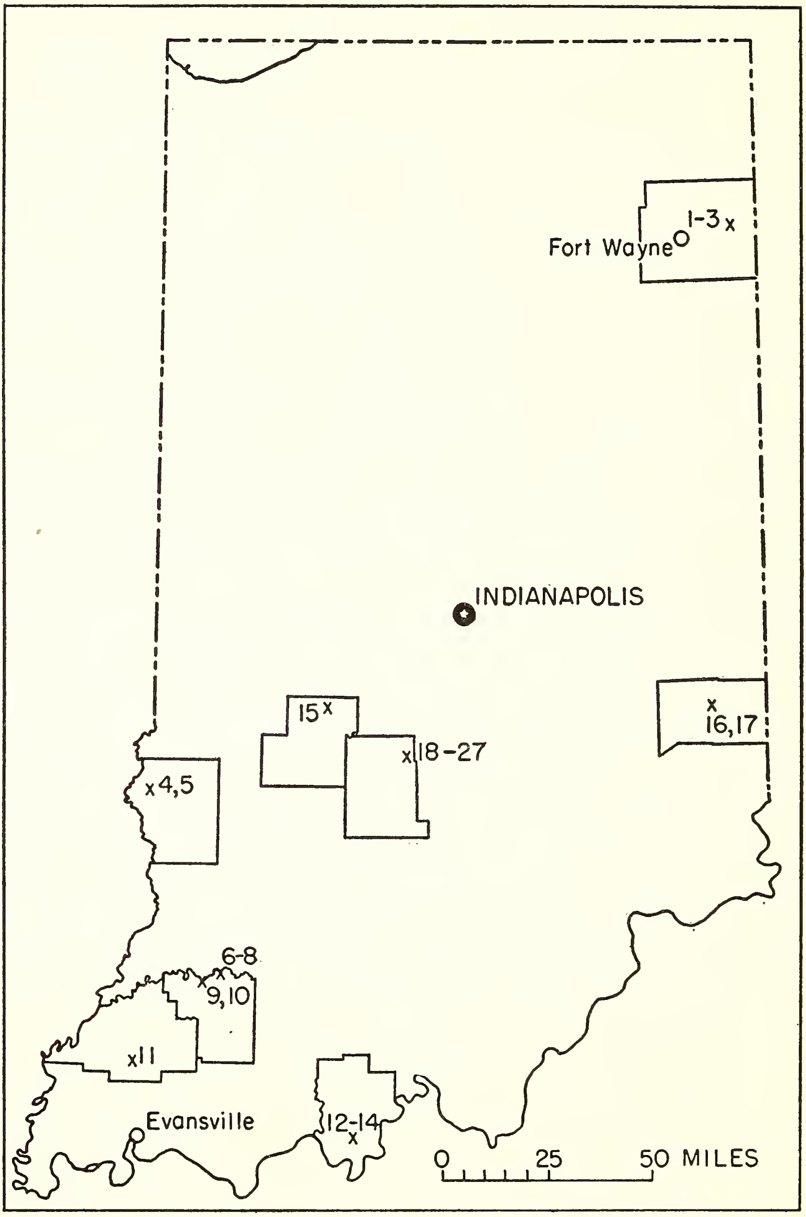

Figure 1. Map of Indiana showing collecting localities and sample numbers of glacial lake clays.

The samples were split into two 30-gram and one 50-gram representative portions by means of a riffle sampler. A Bouyoucos type hydrometer was used to obtain size analysis. After the material had been completely dispersed in distilled water by the addition of sodium hexametaphosphate and vigorous stirring with a mechanical mixer, the hydrometer was introduced at selected time intervals. Cumulative curves of particle size distribution were plotted, and the sorting coefficient was calculated according to the method used by Trask (11).

A Beckman model-G battery-operated pH meter with extension glass electrodes was used to obtain the pH. A 30-gram sample was allowed to stand in distilled water in a 1,000 ml beaker for 60 hours before the pH was determined.

Grim (4) pointed out that a separation at 2 microns is generally the optimum size for a split of the clay minerals from the nonclay minerals in natural materials. According to Stoke's law, particles greater than 2 microns settle out of an 8-inch column of water after 6 hours. In order to obtain the less than 2-micron portion, the samples were stirred vigorously with a mechanical mixer and then allowed to settle. Material which remained in suspension after 6 hours was siphoned off and was used to make oriented slides following the procedure outlined by Grim (2).

In addition to the slide of the less than 2-micron minerals a slide of the less than 0.5-micron portion was prepared by allowing the material to settle for 64 hours before inserting the glass slide. After the slides had been made, the water was evaporated from the beakers, and differential thermal analyses of less than 2-micron material were run. The apparatus used was similar to that described by Grim (3). A heating rate of approximately 10° C. per minute and a resistance of 20 ohms on the recording circuit were used.

The oriented clay minerals on the glass slides were identified by using a General Electric XRD-3 spectrogoniometer with nickel filtered copper radiation with settings of 50 kilovolts and 16 milliamperes.

In order to determine if material with a 14.2 Å spacing was montmorillonite or chlorite, the slides were treated with glycol and re-run. If montmorillonite was present, glycol, which is a polar organic compound caused the montmorillonite lattice to expand to approximately 17.7 Å. If the 14.2 Å spacing did not change, chlorite was indicated.

After the addition of glycol, the slides were heated to 450° C. for 1 hour. The loss of the 7 Å and the 3.5 Å reflections indicates the presence of poorly crystalline chlorite (6). If these reflections remain, the mineral is probably kaolinite.

X-ray powder diffraction data were obtained from the original material in order to identify nonclay minerals present. In addition, an optical microscope was used to identify minerals retained on the 300-mesh screen. Heavy minerals were not common enough to warrant a heavy mineral separation.

Results of Investigation

The pH values of the samples ranged from 6.99 to 8.69. A range of 8.0 to 8.4 was reported by Rankama and Sahama (8) for natural calcareous lake and river waters. In general, the upper samples in a section had lower pH values, as would be expected in zones where carbonates had been partly leached. The pH of the leached clays ranged from 6.99 to 7.88 and the average reading was 7.36. The pH of the unleached or calcareous clays ranged from 7.77 to 8.69 and the average was 8.21.

Hydrometer readings were taken at intervals of half a minute, 1 minute, and 2, 4, 8, 15, and 30 minutes and at intervals of 1 hour and 2, 4, 8, 24, 36, and 48 hours. A Casagrande nomographic chart was used for calculating grain diameter of the samples. Cumulative curves showing results of the hydrometer analyses were plotted. Quartiles of particle size distribution were calculated according to the method of Krumbein and Pettijohn (7) and the sorting coefficient was calculated from the quartiles. The average sorting coefficient value was 1.94 well below the 2.5 value Trask indicated for a well-sorted sediment.

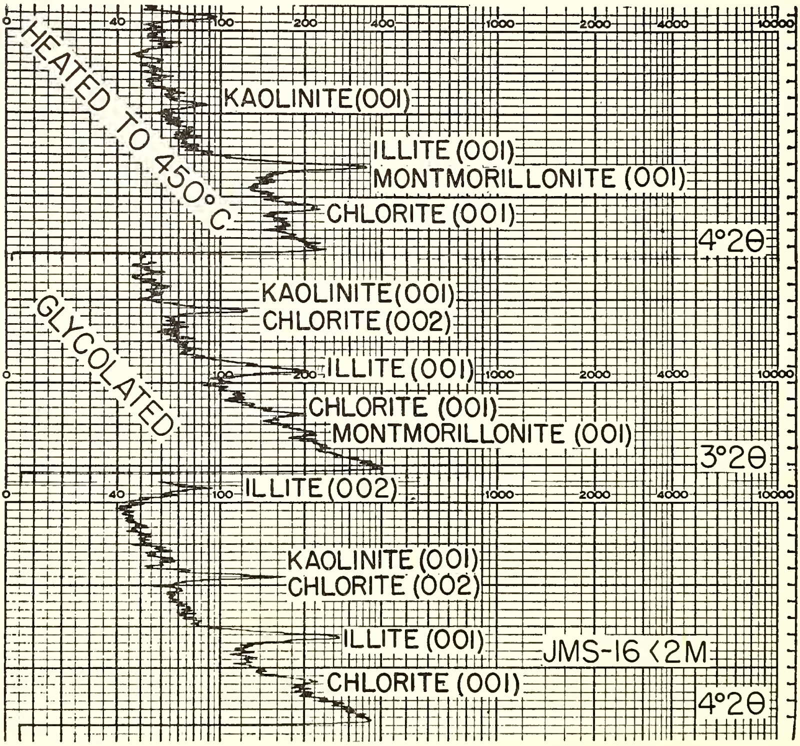

Figure 2. X-ray spectrogram of original sample JMS-16.

X-ray analysis of the original samples showed that quartz was the most abundant nonclay mineral and that calcite, dolomite, and feldspar were in most samples in varying amounts. Some samples contained small amounts of iron in the form of hematite. Figure 2 shows a typical X-ray spectrogram of an original sample.

Material retained on the 300-mesh sieve was examined with a polarizing microscope. Of the major components quartz was found to be the most abundant mineral and the carbonate minerals were the next most abundant. Feldspar was present in nearly all samples. Large amounts of organic material were found in most samples. Nearly half of the samples contained brown opaque minerals, some of which were magnetic and apparently coated with limonite. Minor constituents included a wide variety of both stable and unstable heavy mineral species.

X-ray diffraction data were obtained from untreated oriented slides of the less than 2-micron and less than 0.5-micron portions after they were saturated with glycol and heated to 450° C. Figure 3 shows a

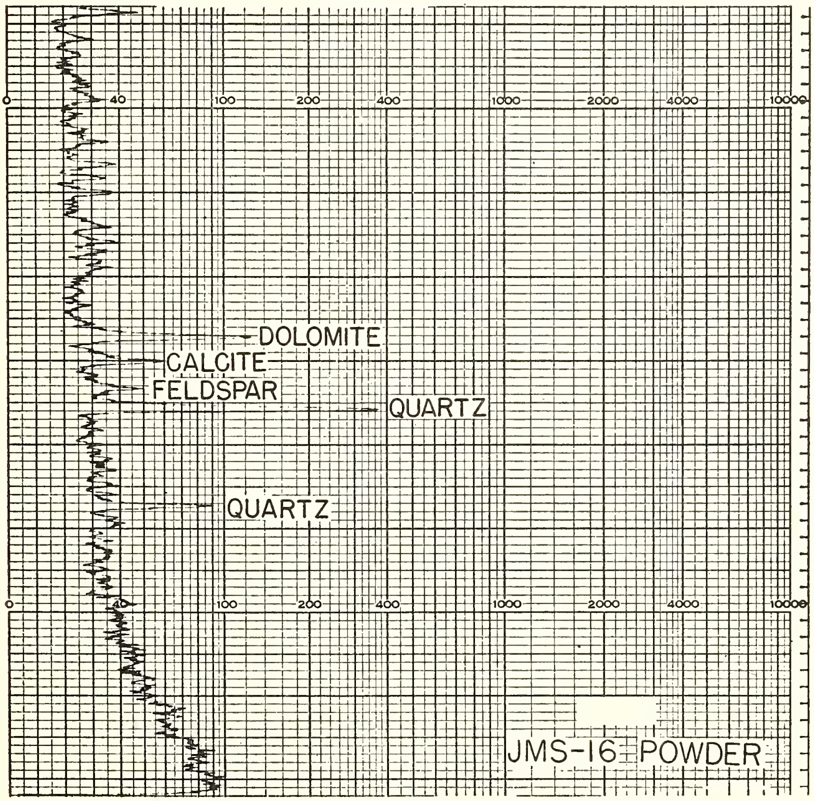

Figure 3. X-ray spectrogram of untreated glycolated and heated slide, JMS-16, less than 2-micron portion.

typical X-ray spectrogram of the less than 2-micron portion.

Because of the similarity of the clay minerals found in this study to those in Recent sediments, the procedure for quantitative estimates of amounts of clay minerals present in the samples, suggested by Johns, Grim, and Bradley (6), was followed in the interpretation of results.

Illite was found in all samples and was the predominate clay mineral in all but 6 samples; in these 6 chlorite was the most abundant clay mineral. Montmorillonite was found in minor amounts in nearly all samples and was predominant in one sample. Kaolinite was present in small amounts in nearly half of the samples analyzed. A few samples showed mixed layering of illite, chlorite, and montmorillonite, but the amount of each was very small and thus was not considered in the semiquantitative estimates. Colloidal quartz was present in varying amounts.

In general, the same minerals that were found in the less than 2-micron portion were predominate in the finer portion. However, a marked reduction in the amount of illite and an increase in the amount of chlorite occurred in the less than 0.5-micron portion. Montmorillonite and kaolinite were less common in the finer portion. Some samples showed mixed layering of illite and chlorite, but the amount of mixed-layered material was insignificant. Colloidal quartz also was present in varying amounts.

Differential thermal analysis supplements X-ray data and provides some information that cannot be derived from X-ray diffraction analyses. Organic material is not detectable by X-ray diffraction techniques but is indicated on differential thermal curves by a broad exothermic reaction that begins at approximately 200° C. and ends at about 500-600° C. Differential thermal reactions for the various clay and nonclay minerals were described by Grim and Rowland (5) and, therefore, are not discussed in detail in this report.

Illite was the major clay mineral indicated on more than half of the differential thermal curves. Chlorite although present did not give reactions diagnostic enough to be recognized. Organic material was present in amounts ranging from a trace to extreme abundance. Differential thermal analyses indicated the formation of a calcium silicate compound at 850° C. when colloidal $CaCO_3$ and SiO_2 were present in sufficient quantity. An X-ray powder photograph verified the formation of this compound $CaO._3(MgFe)0.4SiO_2$.

Discussion of Results

The data indicate that the clay minerals in the lacustrine deposits sampled are, in order of abundance, illite, chlorite, montmorillonite, and kaolinite.

The rocks which contributed detrital materials to the glacial lakes in Indiana are very diverse. The most important contributors of detrital materials to the lakes were the sedimentary rocks of Indiana. Some materials were derived from rocks on the Canadian shield and from rocks in areas crossed by glaciers south of the shield area. Within Indiana, the most important contributors to the lacustrine deposits were the sedimentary rocks of Silurian, Devonian, Mississippian, and Pennsylvanian ages.

The Silurian system is composed mainly of limestones and dolomites. The Waldron shale (Silurian) may have contributed minor amounts of clay minerals to lacustrine areas in southeastern Indiana. The Waldron is composed predominantly of illite; kaolinite along with mixed-layer clay minerals is second in abundance. The Devonian system in Indiana is mainly dolomite and dolomitic limestones, but the top of the Devonian is composed of the thick New Albany shale which contains abundant illite and kaolinite. The Borden group (lower Mississippian) consists predominantly of shales and siltstones. The major clay minerals in the rocks of the Borden group, in order of abundance, are illite, chlorite, and kaolinite. The Meramec series is made up primarily of carbonate rocks and contributed very little clay to the Pleistocene lakes. The Chester series (upper Mississippian) is composed of alternating sandstone, shale, and limestone. These rocks contributed clays which in order of abundance are illite, kaolinite, chlorite, and mixed-layer minerals. Pennsylvanian sedimentary rocks are now found only in southwestern Indiana; these rocks are soft and easily eroded. The Pennsylvanian rocks contain far more clay minerals than do the rocks of any other system in Indiana. These rocks are cyclic in nature and are composed of sandstones, siltstones, shales, underclays, coals, and thin limestones. The Pennsylvanian sedimentary rocks contributed large amounts of clay minerals to the glacial lacustrine areas of southwestern Indiana. The clay minerals found in these rocks are in order of relative abundance: illite, kaolinite, chlorite, and mixed-layer minerals.

Other sources of clay for the glacial lakes were preglacial soils which resulted from the weathering of bedrock. Reworked Illinoian glacial materials were important sources for Wisconsin lake sediments in some areas. In addition, wind-blown materials are found in a few of the lacustrine deposits.

According to Grim (4) the chief clay mineral components found in calcareous sediments (including dolomites) are illite and montmorillonite. Grim also states that in the weathering of kaolinite clays, such as some Pennsylvanian underclays in which there is no appreciable content of alkalies or alkaline earths, illite and montmorillonite cannot be formed because potash and magnesia are necessary for their formation. Muscovite and biotite can change to illite by a slight structural rearrangement without any breakdown to ionic or colloidal components (4).

Data from Grim (4) indicate that in sediments of lacustrine origin where salts and carbonates are likely to accumulate, the dominate clay mineral components are illite and montmorillonite.

A general study of source materials for the lacustrine areas in Indiana indicates that the following minerals are present in order of abundance: illite, chlorite, kaolinite, and montmorillonite.

Sample analyses show a slight enrichment of chlorite or reduction in the amount of kaolinite, for these two minerals are present in approx-

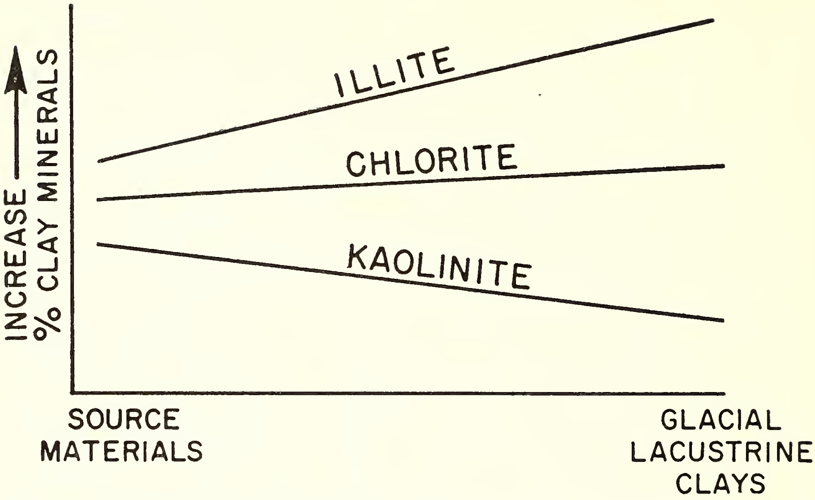

Figure 4. Diagram showing relative abundance of clay minerals in source materials and lacustrine clays.

imately equal proportions in the source rocks. Figure 4 shows a generalized diagram showing relative abundance of clay minerals in source materials and in the lacustrine deposits. No explanation to account for this difference in amounts of clay minerals in source materials and in lacustrine deposits is readily apparent unless a source area north of Indiana may have contributed a large amount of chlorite. Illite is more abundant in the lacustrine sediments than in the source rocks. Enrichment of illite can be explained in part by the breakdown of micas found in the source rocks to illite. Moreover, if potassium ions were available in the lake waters, illite could have been produced by the adsorption of K^+ by montmorillonite. K^+ has the lowest ionic potential of any ion that would be in solution and therefore might be adsorbed preferentially. Colloidal quartz in the samples may represent colloidal silica produced by weathering of the source rocks.

The great variability of rock types in the possible source areas and the complexity of the transporting agents make conclusions regarding provenance of the glacial lacustrine clays very difficult. The following generalizations may be made regarding the clay minerals:

1. Nearly all the clays are detrital except for some montmorillonite which is a weathering product.

2. The size and shape of clay minerals permit them to be carried great distances without deposition or change in character. These clay minerals may have been deposited and re-eroded many times before deposition at their present location.

3. No pronounced differences were observed between clay minerals in the sediments of Illinoian and those of Wisconsin age.

4. The source-rock constituents were the main controlling factors in the type of clay minerals deposited in the lacustrine areas. The transporting agent or environment of deposition apparently had little influence on the clay minerals, probably because these sediments were deposited rapidly in relatively short-lived glacial lakes.

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Water Supply Problems of Bloomington, Indiana

STEPHEN S. VISHER, Indiana University

Most of the world has water supply problems; fully one-fourth of the land is arid and another one fourth is semi-arid, about one fifth of the land, although for the year as a whole the total rainfall is sufficient to raise it above the semi-arid level, has pronounced dry seasons. Dry summers are characteristic of the Mediterranean climates, of which California is the American representative; dry winters are features of the Monsoon climates and also of considerable of interior Asia and North America. About one eighth of the land is so cold in winter that pure water is obtained only with difficulty, perhaps by melting snow or ice. Hence less than one fourth of the world is humid nearly all the year, but even there, dry spells occur occasionally in all seasons. In Indiana, for example, nearly every summer has two consecutive weeks with little or no rainfall; sometimes almost no rain falls for a month (1). Comparative studies reveal that Indiana is more fortunate in this respect than are most of the so-called humid regions (2).

The great increase in the demand for water associated with increased population, higher per capita demand, industrialization, and the desire for more adequate water supplies for crops and domestic animals has resulted in water supply problems in many places which formerly seldom had a water shortage. Despite the considerable progress which has been made to alleviate water shortages, it appears highly probable that increased difficulties will arise very widely.

One way to prepare for the future is to make local studies of the past and present. This paper presents information concerning water supply problems of Bloomington, Indiana, and of the methods taken to alleviate them. Bloomington's average annual precipitation of about 45 inches normally well distributed among the twelve months supplies enough water, if it were all available, to more than meet human needs. Unfortunately much of the rainfall swiftly runs away. Moreover, spells with little or no rain are fairly frequent in summer and occasional in autumn and winter. Much of the total rainfall occurs rapidly, in downpours which frequently almost merit the appellation "cloudburst" often applied to them. Of the year's total downfall, fully a third is of this type, another third is moderately heavy rain, and the remainder falls as gentle rains, which although they occur during many more hours than do the torrential rains, yield a smaller total of water (4).

The percentage of the rain which runs away has increased as a result of the loss of much of the absorbent forest litter which formerly was widespread in this naturally wooded region, and with the removal by soil erosion of considerable or all of the comparatively spongy topsoil from the large percentage of land which has considerable slope in this unglaciated area. Rain which falls on clay subsoil or upon bare rock necessarily nearly all runs away.

Man has increased the runoff also by the construction of drainage works, by the paving of streets, sidewalks and even of alleys, and by the construction of rain-shedding buildings.

The water supply needs of Bloomington have increased enormously with the growth of the city, with increased per capita needs, and with the demand for more water for industries, fire protection and sewage disposal.

Accompanying the increasing needs and decreasing natural supply, there have been significant changes in the sources of Bloomington's supply. During the town's early years (1816-1890) one of the assets often mentioned was the numerous springs, maintained by water which had entered sink holes at somewhat higher altitudes surrounding the town. But as the population grew, and spread from the depression in which the town was established the water entering the sink holes during and shortly after rains soon became contaminated. For many decades Bloomington had a relatively high death rate from typhoid fever (3), which fact stimulated the abandonment of the springs which had been so prized in early years. Wells failed to yield a safe water supply largely because the limestone upon which Bloomington is situated is cavernous, and hence the water flowing through it is not properly filtered. At a depth below the limestone, the rock formations contain relatively little water and that normally is bitter or saline (5).

Cisterns were built by many of the more substantial citizens of Bloomington after they were convinced that springs or well water was unsafe or undrinkable. However, the dry spells which, as already remarked, occur rather frequently in summer and autumn, rendered small cisterns inadequate, and the fact that the rock is close to the surface made the construction of large cisterns expensive.

Hence Bloomington sought a city water supply. It so happens that southwest of Bloomington there are a series of ponds, locally called lakes, in large sink holes, the downward outlets of which had been sealed by the stiff clay which is derived from the decomposition of the limestone. These ponds are fed by springs, the outlets of rain water which had entered lesser sink holes at a higher altitude. As the ponds were all shallow and contained only a small amount of water, dams were constructed across their surface outlet to raise the water level to increase their storage capacity. The first such pond used is just west of the present city limits; the next are about a mile further southwest, the so-called Twin Lakes; about a mile still further away is Weimer's Lake, and a couple miles further is Leonards Spring Lake. The city constructed a dam to raise the water level in each of these ponds, the first in 1894, and others in 1907, 1909, and 1915. Unfortunately, shortly after the water level was raised by the dam, the increased pressure of the water cleared the sealing clay from some crack in the cavernous limestone and hence much water escaped through the cavity. Various influential citizens refused to accept the conclusions of geologists that reservoirs in the limestone were not feasible. As each new reservoir served for a time (until some crack was cleared of its plug of clay) the city made renewed efforts to store water in that limestone area by constructing additional dams.

In especially dry summers and autumns the water shortage became so acute that serious consideration was given in other parts of the state of the desirability of moving Indiana University to some other city. However, the University's president, a native of Bloomington, opposed the plan to move the University, and called upon two professors of geology and a professor of physics for advice as to what could be done (6). Fortunately the limestone beds upon which Bloomington is situated extend only a short distance east of the city. In the shale which out crops east of the limestone margin a reservoir which does not leak can be constructed. The University built "the University Dam" in 1910 and it proved successful. Although the reservoir was far too small to serve the city, the lessons taught by the failure of the reservoirs in the limestone and the success of the one on the shale led the city to construct a far larger dam across Griffy Creek some 3 miles northeast of the city in 1925, and to increase greatly the height of the dam in 1940. However, the demand for water grew rapidly with the great growth of the University and the coming to Bloomington of the electronics industry established by a highly talented immigrant. That industry itself requires little water, but the workers and those who supply services of various sorts to employees and students desire much water, as did those who constructed the many new buildings, streets, etc. By 1952 a severe water shortage again occurred, in an exceptionally dry summer. Fortunately for Bloomington, a favorable site for a dam across a quite sizable stream (Bean Blossom Creek) is present about 12 miles northeast of Bloomington. A progressive young mayor succeeded in having the dam constructed (completed in 1953), and now Bloomington has enough water to last for a long time. The expense of bringing the water to the city is lessened by the fact that Bean Blossom Creek happens to come within about two miles of the city dam across Griffy Creek. The water is permitted to flow down Bean Blossom Creek to that point, and then is raised by pumping only a few score feet to the main city filteration and pumping system just below the Griffy Creek dam.

The fact that Bloomington is on a drainage divide between the East Fork and West Fork of White River results in its being some distance from a sizable stream, and makes it necessary to raise the water some 250 feet from the reservoir to the storage tanks in the city. But this situation on a divide reduces flood danger to a minimum, and made the site more healthful in early years when malaria was wide-spread on poorly drained land in Indiana.

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Road Patterns of Indiana

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The present road patterns of Indiana reflect both the topography and history of the state. Even state road maps differentiate sharply between the irregular road patterns in unglaciated Indiana and the rectangular road patterns predominant elsewhere. On state road maps likewise the location of Indian trails and early trunk roads can be approximately traced from the course of modern highways; examples are U. S. 150 (the Buffalo Trace), U. S. 40 (the National Road) and U. S. 421 (the Michigan Road).

The local roads shown on the detailed county road maps reflect the topography and history of the state in even more clearcut patterns. In most of the state the influence of the early surveys appears in the common checkerboard pattern. The irregular ridge and valley pattern common in the unglaciated and little glaciated areas reflects the lack of gentle slopes on the hillsides. Finally near water bodies local road locations are commonly influenced by drainage problems.

It should be emphasized that patterns on roads used for through traffic are often different than the local road patterns. The through routes (generally but not always numbered state or federal highways) radiate from the principal centers; for example, 15 routes radiate from Indianapolis and 12 from Fort Wayne. Especially where traffic is heavy, through routes cut across survey lines and minor topographic features and the tendency is for these routes to become more direct. Relict bits of older road are common features along such routes and result from the desire to speed up traffic and eliminate dangerous curves by straightening the road. An especially striking example of road realignment is State 37 between Martinsville and Mitchell.

In northwestern Indiana some of the through routes follow the section lines, notably U. S. 35, 41, 231, and 421. But even in this level area most of the through routes cut more or less diagonally across the survey grid. A study of detailed topographic maps shows that many of the roads appear straighter on the state road maps than they actually are; for example, U. S. 40 east of Indianapolis at a glance appears to follow the section lines but nowhere does it do so.

The predominant pattern for local roads is the rectangular or checkerboard pattern. The area with this pattern is shown on Figure 1 in white. Throughout the area the majority of the local roads either follow or are parallel to the section lines. The roads are most commonly one mile apart, at most one mile and a half, and in thickly settled sections one-half mile apart. In some counties, for example Grant, Hancock, and Madison, the checkerboard pattern is so regular that the roads almost coincide with the section lines; everywhere in central and northern Indiana conformity of roads to section lines is common. Minor departures from the section lines to avoid streams, ponds, and moraines are not unusual but are often so slight as to be unnoticeable on small-scale maps.

The checkerboard road system is not a particularly efficient system. Its right-angle corners slow down traffic. To get to a point to the northwest, northeast, southwest, or southeast of the starting point involves a journey of 10 miles for every 7 miles airline distance if no diagonal roads are available.

The great advantage of the section-line checkerboard was the ease with which its roads could be laid out. County roads were opened by petition[1] and the work was performed by the settlers after approval by the County Commissioners. As each man was obligated to work six days a year on the roads, there was a tendency to advocate the easier routes. When the land was first surveyed, the surveyors blazed the trees and cleared the underbrush along the section lines. The corners of each quarter section were also marked. Thus, if a county road became desirable, it was easier to follow a line already surveyed and partly cleared. Furthermore, the section-line roads took but a little land from each of the adjacent properties nor did they cut across farmsteads or upset the rectangular field pattern.

The checkerboard road pattern is also common in southern Indiana and predominates in the Wabash Lowland, the Mitchell Plain, the Scottsburg Lowland and the Muskatatuck Regional Slope. Local modifications to avoid sinkholes, ponds and streams are more common than to the north but these are minor irregularities in areas of generally straight roads and right-angle bends. Another irregularity occurs in Clark and Knox counties where road grids are diagonal to the township-range survey but parallel to the old survey grid.

The second typical road pattern (stippled on Figure 1) is an irregular network of ridge and valley roads. The road grid is somewhat more open than in the checkerboard area; nevertheless there are only five places in all southern Indiana where the local roads are more than two miles apart. The poor quality of these roads with their many steep grades, sharp curves, and rough pavements makes them less suited for traffic than the checkerboard roads. The typical road in this area uses the ridge tops as much as possible, descending briefly into the valley and then climbing up an opposite spur. This road pattern is almost universal in the Crawford, Norman, and Dearborn uplands and in a few scattered areas elsewhere.

The third typical pattern (black on Figure 1), is found along major streams and other water bodies throughout the entire state. In many places the road network of the better-drained adjacent area breaks off abruptly as the flood plain is approached. More commonly a road parallels the stream or lake but keeps some distance from the water's edge. Where stream crossings or local access to farmsteads is desired, spur roads branch off from the main road.

As traffic is increased and old roads are realigned, these regular patterns may be expected to become less conspicuous. Advances in roadbuilding machinery and the growing belief that straight roads are not necessarily the safest for driving, may give rise to new patterns.

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[1] See Esarey, Logan. 1953. The Indiana Home, Bloomington. pp. 105-7.

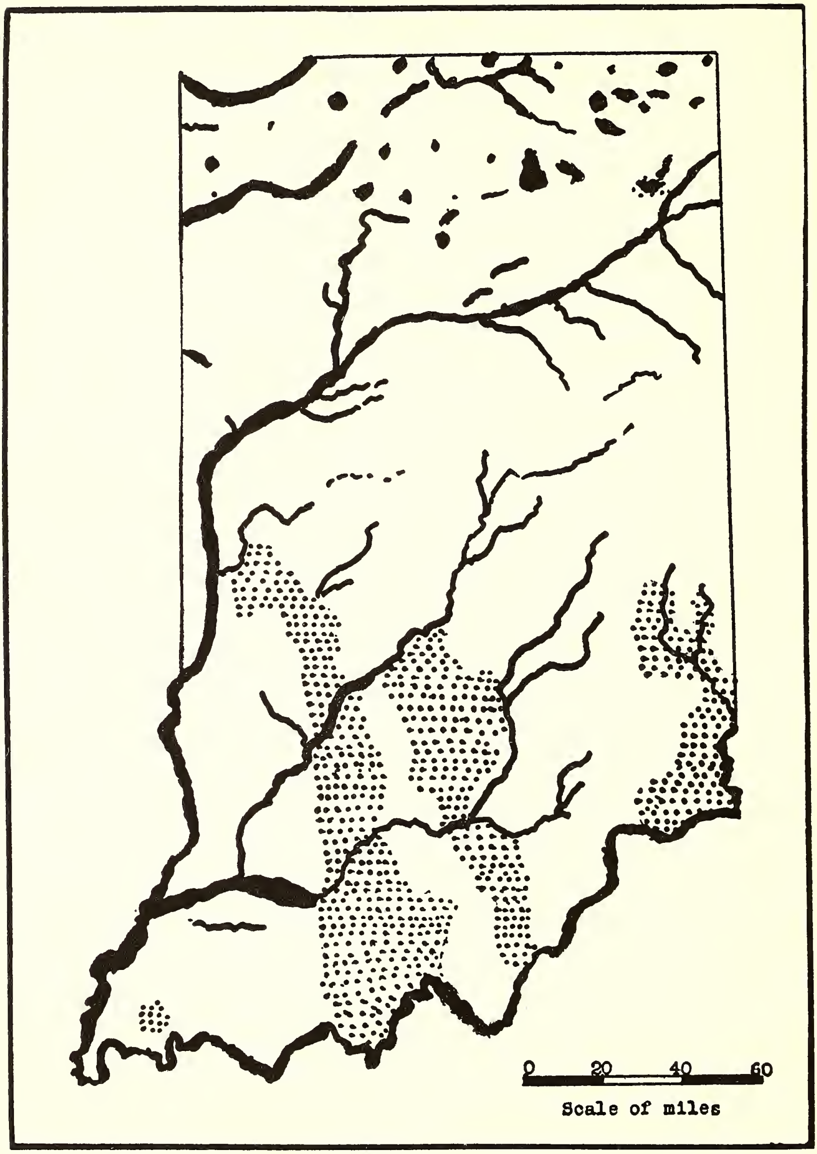

Figure 1. Local Road Patterns of Indiana. The white areas have a rectangular or checkerboard pattern. The stippled areas have ridge and valley roads. The black areas are influenced largely by water bodies.

The relief of Indiana is not so great that the course of routes need be accommodated to it if modern engineering equipment is available. Hence the failure to cut roads across relief features and the survey pattern indicates that the traffic is so modest that the redesign of the route is uneconomical.

Migration and Population Change in Indiana

JOHN F. HART, Indiana University

In the words of Dudley Kirk, "People are born, they die, or they move; these are the components of population change" (1). In the United States data are readily available on the number of births and deaths each year in each county and in each city of ten thousand persons or more (2), but adequate data on migration are somewhat harder to obtain. This is indeed surprising in view of the traditional mobility of the American people; at the time of the 1950 Census of Population one of every six Americans over one year old had moved to a different house within the preceding year, and one of every sixteen had moved to a different county (3).

It is the purpose of this paper to consider population migration to, from, and within Indiana, insofar as this migration can be estimated from published statistics. We will follow two main lines of attack. First, analysis of the net resultant of migration by all persons living at the time of the 1950 Census of Population is based on the Special Census Report on Mobility of the Population (4). Second, analysis of migration between 1940 and 1950 is based on comparison of population change, as reported in the 1950 Census (5), with vital rates for each year, as reported in Vital Statistics of the United States (2). Two other measures of migration were explored, but have serious flaws for geographic purposes: change in residence between 1949 and 1950 is too heavily weighted for those places with large student populations (6); length of farm tenure is reported for areas too large to have significance in a geographic survey of a single state (7).

The Net Resultant of Migration

In 1950 a total of 4,875,430 people, including 195,655 nonwhite persons, had either been born in Indiana or were living here; these are the "Indiana people" of the first figure (Fig. 1). Only 2,853,140 of these five million people were both natives and residents; 957,750 natives of Indiana were residents of other states in 1950, whereas 940,555 natives of other states were living in Indiana. The resultant net change by inter-state migration (–17,235) was a loss of less than half of one percent of the 1950 population. In contrast, more than half (104,520) of the state's nonwhite population in 1950 was a product of interstate migration. Approximately one-third (67,350) of Indiana's nonwhite people were both natives and residents, whereas little more than ten percent (23,785) were natives who had moved to other states.

Adjacent states were the prime sources of Indiana's migrant population (Fig. 2). Taking the stream of migrants as a whole, more than twenty percent each came from Illinois and Kentucky, more than ten percent from Ohio, and more than five percent each from Tennessee

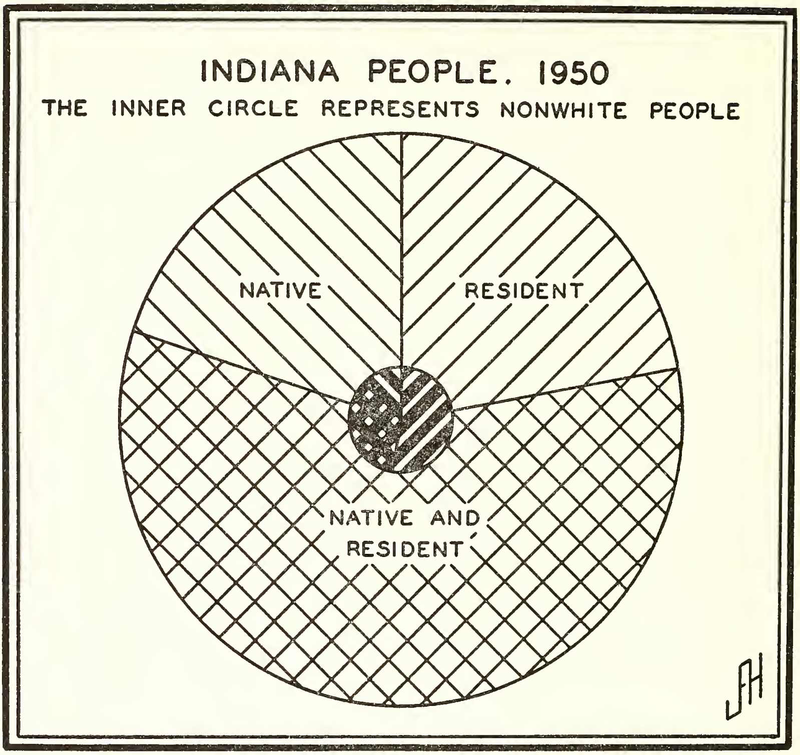

Figure 1

and Michigan. Pennsylvania, Missouri, and Mississippi were the only other states contributing more than two and a half percent. Excluding New England, the majority of states east of the Great Plains contributed at least half of one percent of the total flow, whereas relatively few migrants came from states west of the Rockies.

The major migrant magnets for Indiana natives were adjacent states to the north, and California (Fig. 3). Four states, Illinois, California, Ohio, and Michigan, each took more than twelve percent of all migrants, whereas the next highest, Kentucky, took only four. The other states taking more than two percent of the total flow were Florida, Texas, Missouri, Washington, and New York. There was relatively slight migration to New England or to the South, but considerable movement westward, and especially to the three West Coast states.

The diagram of migratory trends minimizes the effects of migration to and from adjacent states, a movement which may merely represent minor shifts of residence across state lines in many instances (Fig. 3). Ohio, for instance, provides more than ten percent of Indiana's immi-

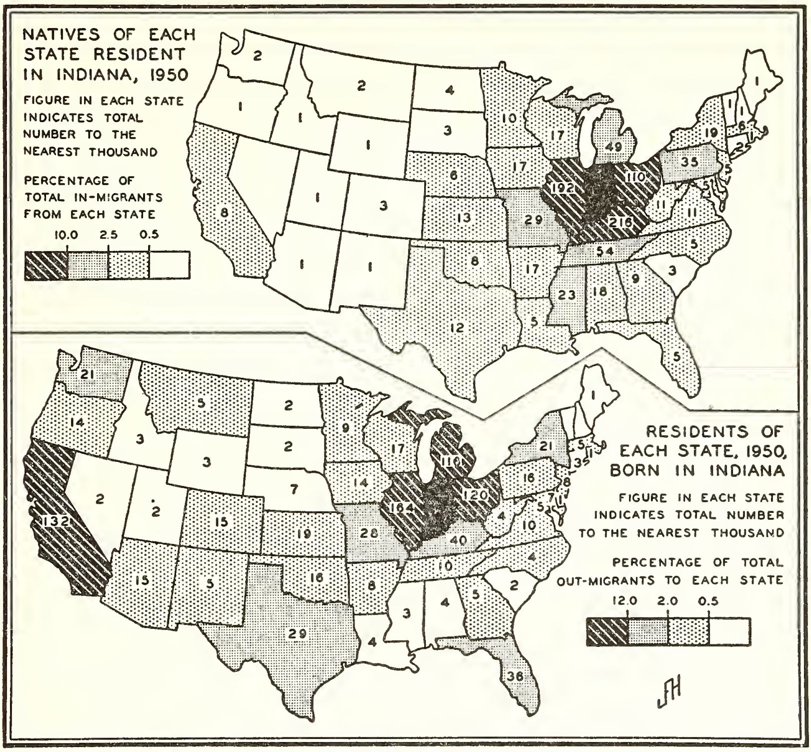
NATIVES OF EACH STATE RESIDENT IN INDIANA, 1950
FIGURE IN EACH STATE INDICATES TOTAL NUMBER TO THE NEAREST THOUSAND
PERCENTAGE OF TOTAL IN-MIGRANTS FROM EACH STATE
10.0 2.5 0.5
RESIDENTS OF EACH STATE, 1950, BORN IN INDIANA
FIGURE IN EACH STATE INDICATES TOTAL NUMBER TO THE NEAREST THOUSAND
PERCENTAGE OF TOTAL OUT-MIGRANTS TO EACH STATE
12.0 2.0 0.5
JH

Figure 2

grants, but receives more than ten percent of the state's emigrants; the two movements cancel each other. On the other hand, Kentucky receives few emigrants but provides a large proportion of the immigrants, whereas just the reverse is true of California. When net migration alone is considered, it is evident that the major flow of migrants to Indiana comes from four states in the middle South, with lesser numbers from the east and northern mid-West. The major migratory trend of Indiana natives is westward, with lesser movements to Michigan and Florida, and a small share to the New York and Washington metropolitan areas. It is apparent from this map that the young men and women of Indiana who took Horace Greeley's famous advice have been replaced by immigrants from the South.

Urbanization, Migration, and Rates of Natural Increase

Although precise quantitative correlation is impossible, there are broad general relations between urbanization, migration, and rate of natural increase in Indiana between 1940 and 1950. This fact facilitates discussion of Indiana's cities and counties, inasfar as migration and natural increase are concerned, in the following five categories:

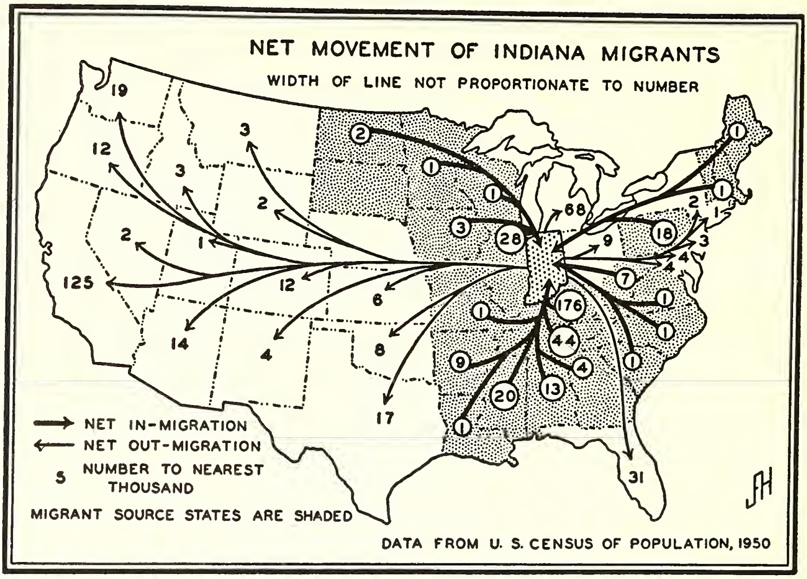
NET MOVEMENT OF INDIANA MIGRANTS
WIDTH OF LINE NOT PROPORTIONATE TO NUMBER
19
12
3
3
2
2
1
125
12
6
14
4
8
17
2
1
3
28
68
9
18
2
1
1
1
3
4
7
176
1
1
44
1
9
4
13
20
1
31
1
NET IN-MIGRATION
NET OUT-MIGRATION
5 NUMBER TO NEAREST THOUSAND
MIGRANT SOURCE STATES ARE SHADED
DATA FROM U. S. CENSUS OF POPULATION, 1950
JH

Figure 3

(1) metropolitan cities, including all cities of more than ten thousand persons in standard metropolitan areas.

(2) metropolitan counties, including all counties in standard metropolitan areas.

(3) small cities, including all cities of more than ten thousand people in 1940.

(4) small city counties, including all counties which contain small cities.

(5) rural counties, which had no city as large as ten thousand in 1940.

Natural Increase, 1940-50

The natural increase is the surplus of births over deaths. For comparability with Census data, the number of deaths of residents in every Indiana city and county during the ten intercensal years 1940-49 were totalled, and the total number of deaths was subtracted from the total number of births during this same period (2). The surplus of births over deaths was divided by the total 1940 population to produce a figure representing the rate of natural increase; the rate of natural increase is interpreted equally correctly as a percentage of the 1940 population, or as the average number of new persons each year per thousand persons in 1940.

The highest rates of natural increase in Indiana for the decade 1940-50 were in urban areas (Table I). For the state as a whole the rate of natural increase was 11.4, whereas metropolitan cities had a

TABLE I

INDIANA, 1940-50

POPULATION CHANGE AND MIGRATION BY SIZE OF PLACE

Size of Place	1940 Population	Natural Increase 1940-50	Net Increase 1940-50	Number of Migrants	Rate of Natural Increase	Rate of Migration
The State	3,427,796	392,796	473,534	81,231	11.4	2.4
All urban places	1,567,600	208,465	194,815	–13,650	13.2	–0.9
Metropolitan cities*	1,128,177	153,375	150,708	–2,667	13.6	–0.2
Small cities*	439,423	55,090	44,107	–10,983	12.6	–2.5
All urban counties	693,454	78,922	216,315	137,393	11.3	19.8
Metropolitan counties*	314,387	39,103	151,942	112,839	12.4	36.0
Small city counties*	379,067	39,819	64,373	24,554	10.5	6.5
Rural counties	1,166,742	104,916	62,404	–42,512	9.0	–3.6

*Metropolitan cities: East Chicago, Evansville, Fort Wayne, Gary, Hammond, Indianapolis, Jeffersonville, Mishawaka, Muncie, New Albany, South Bend, Terre Haute, Whiting.

Small cities: Anderson, Bedford, Bloomington, Crawfordsville, Columbus, Connersville, Elkhart, Elwood, Frankfort, Goshen, Huntington, Lafayette, La Porte, Logansport, Kokomo, Marion, Michigan City, New Castle, Peru, Richmond, Shelby, Vincennes.

Metropolitan counties: Allen, Clark, Delaware, Floyd, Lake, Marion, St. Joseph, Vanderburgh, Vigo.

Small city counties: Bartholomew, Cass, Clinton, Elkhart, Fayette, Grant, Henry, Howard, Huntington, Knox, La Porte, Lawrence, Madison, Miami, Montgomery, Shelby, Tippecanoe, Wayne.

rate of 13.6, and small cities had a rate of 12.6. Conversely, although metropolitan counties had a rate of 12.4, other rural areas lagged behind the state rate. In short, if we completely ignore migration, it would appear that the population of urban areas in Indiana was growing at a more rapid rate than the population of rural areas in the decade 1940-50; this conclusion must be qualified, however, by the fact that we cannot tell the degree to which the higher birth rates of urban areas were produced by fecund in-migrants.

The areas of greatest natural increase were in the northern tier of counties, from Elkhart to Chicago, in the belt running northwestward from Richmond to Kokomo, and in the central southern part of the state (Fig. 4). Smaller areas with comparably high rates of natural increase were found near Fort Wayne, Lafayette, and Indianapolis. The rate of natural increase was relatively low throughout the rest of the state, with a decline to the west; the lowest rates of all were found in the west central part of the state in the counties around Terre Haute and Crawfordsville.

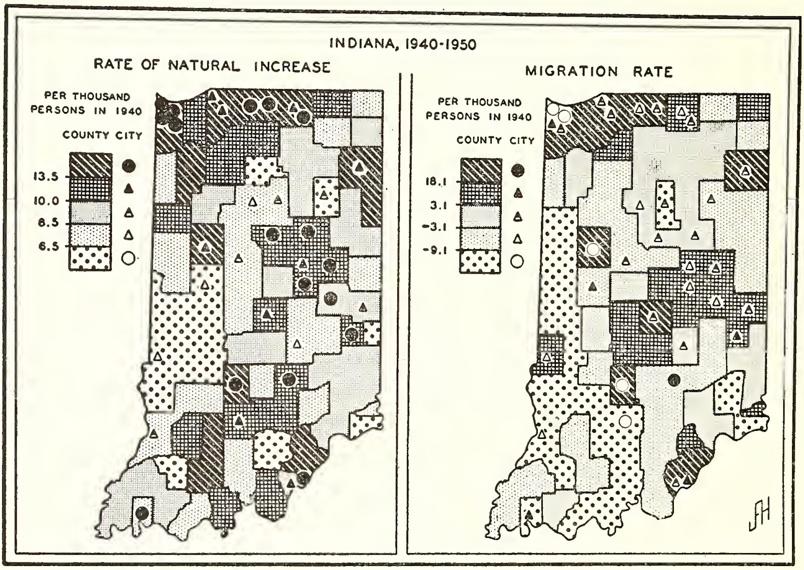

Figure 4

Migration, 1940-50

If there were no migration, the rate of natural increase would be identical with the rate of population growth. Comparison of the two rates, however, indicates considerable variance, which is assumed a product of migration. The migration rate for each city and county, therefore, is computed by subtracting the total natural increase from the net change in population (2, 5, 8), and dividing the resultant figure by the 1940 population. The total enrollment in Indiana colleges in the third week of the Fall Term, 1939, was 32,894 students. The different enumeration of students in the 1950 Census requires that the increase in population be adjusted; here the adjustment was made by subtracting the number of students in 1939 from the total increase of counties or cities with institutions of higher education. The migration rate, therefore, like the rate of natural increase, is the annual average number of migrants per thousand persons in the 1940 population, or the decennial total of migrants as a precentage of the 1940 population.

In the decade 1940-50, rural areas lost population by migration, suburban areas gained, and urban areas lost, but only slightly (Table I). The loss rate was only –0.2 in metropolitan cities, –2.5 in small cities; and –3.6 in rural counties. Small city counties, conversely, had an in-migration rate of 6.5, and metropolitan counties had the astonishing rate of 36.0; the metropolitan counties, in short, increased their population by more than a third as a result of in-migration between 1940 and 1950.

The greatest in-migration between 1940 and 1950 occurred in the northern tier of counties between Elkhart and Chicago, in a crescent-shaped group of counties from Richmond through Indianapolis to Bloomington, and near such metropolitan centers as Fort Wayne, Lafayette, Terre Haute, and Louisville (Fig. 4). It must be noted at once, however, that only six Indiana cities experienced significant in-migration, and only three of these were in the counties with heaviest in-migration. Only seven Indiana cities had higher in-migration rates than the counties in which they are located. It would appear, in fact, that the majority of Indiana's cities were doing little better than holding their own, population-wise, between 1940 and 1950, and that their natural population increase was being steadily siphoned into adjacent rural areas. In short, Indiana cities experienced "the flight to the suburbs."

The heaviest loss through out-migration occurred in the western and southwestern portion of the state, where the majority of counties experienced migration losses equivalent to more than ten percent of the 1940 population. Migration losses were smaller in the central south, whereas the eastern portion of the state registered relatively slight change by migration.

Migration as a Factor in Population Change, 1940-50

Comparison of migration rates and rates of natural increase indicates the importance of migration as a factor in population change in Indiana during the last intercensal decade. Where the rate of out-migration exceeds the rate of natural increase, the population will decrease, whereas it will increase if the rate of natural increase exceeds the rate of out-migration. The division of Indiana cities and counties into seven categories is based on the relation between these two rates.

The greatest increases through in-migration occurred in rural areas in the northwestern corner of the state, in the crescent-shaped group of counties from Richmond through Indianapolis to Bloomington, and adjacent to Fort Wayne, Lafayette, Terre Haute, and Louisville; in each of these areas more than a third to a half of the population increase was a product of in-migration (Fig. 5). Interestingly enough, however, it would appear that a large portion of this increase in rural areas was a result of flight from the city, because sixteen of the twenty-four cities in these areas experienced significant out-migration, and these areas contained all but two of the cities where out-migration removed more than half the natural increase. On the other hand, both Evansville and Columbus had in-migration which more than equalled natural increase, and Hammond, Crawfordsville, and Jeffersonville had in-migration rates at least half as high as the rate of natural increase. One wonders why these five cities, together with Gary, Connersville, and New Albany, were the only Indiana cities to attract significant numbers of migrants between 1940 and 1950.

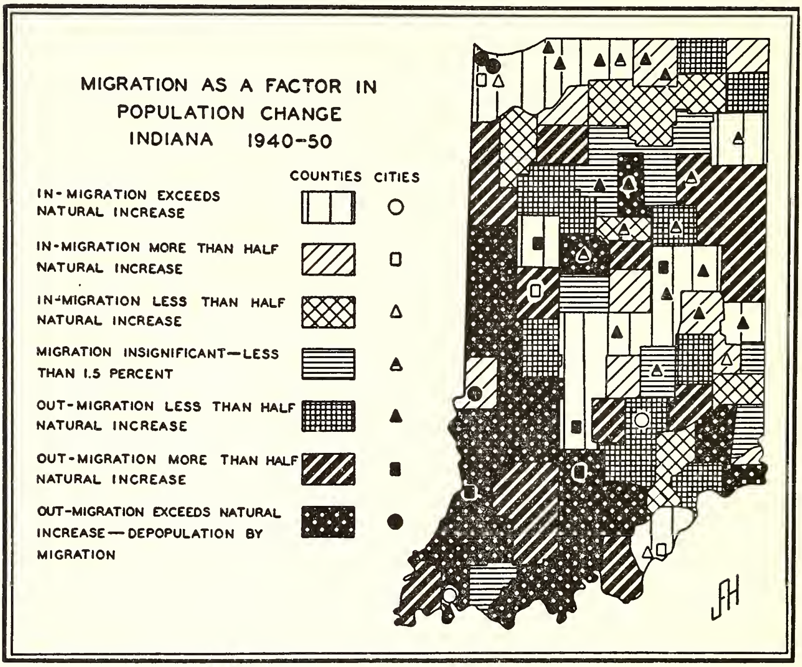
MIGRATION AS A FACTOR IN POPULATION CHANGE INDIANA 1940–50
COUNTIES
CITIES
IN-MIGRATION EXCEEDS NATURAL INCREASE
IN-MIGRATION MORE THAN HALF NATURAL INCREASE
IN-MIGRATION LESS THAN HALF NATURAL INCREASE
MIGRATION INSIGNIFICANT—LESS THAN 1.5 PERCENT
OUT-MIGRATION LESS THAN HALF NATURAL INCREASE
OUT-MIGRATION MORE THAN HALF NATURAL INCREASE
OUT-MIGRATION EXCEEDS NATURAL INCREASE—DEPOPULATION BY MIGRATION
JFH

Figure 5

Counties and cities which experienced only slight net migration, either in or out, are largely in the center of the state. Out-migration removed less than half the natural increase in twelve cities in the central north and central east, but only five cities lost more than half their natural increase by out-migration, and only three, Whiting, East Chicago, and Terre Haute, were actually depopulated by migration.

On the other hand, eighteen counties along the southwestern edge of the state were being depopulated by migration, and depopulation by migration is imminent in those eighteen scattered counties where out-migration removed more than half the natural increase.

It is noteworthy that migration was a more important aspect of population change in rural areas than in urban areas in Indiana between 1940 and 1950. Twenty-two of the state's thirty-five cities (63 percent) are in the three middle categories, whereas only 27 of the state's 92 counties (20 percent) are in these categories. In other words, where migration as a factor in population change is concerned, Indiana's urban areas tend toward the means, but her rural areas tend toward the extremes.

Certain other conclusions might profitably be drawn from this study:

First, westward migration of Indiana natives has been replaced by in-migration from the South.

Second, the traditional demographic division of Indiana into northern, middle, and southern tiers of counties is of slight value in consideration of natural increase and migration, as gradients appear as steep in an east west direction as north-south.

Third, the natural increase of Indiana cities is being siphoned into adjacent rural areas.

Finally, let me suggest that we require investigation of the southwestern part of the state to discover whether there are not some areas which migration has bled white of young people in the reproductive age groups; if this is indeed the case, and I suspect it is, these areas face even more rapid depopulation in the future than has been their lot in the past.

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Population Trends in Indiana's Villages of 1,000-2,500 Population in 1950

Amrit Lal, Indiana University

This paper analyzes the population trends in the incorporated villages of Indiana with a population of 1,000 to 2,500 in 1950 since 1900 and attempts to discover the patterns of distribution of the villages with the different trends.

Contrary to the common notion that the villages in Indiana are decadent, the incorporated villages in this size group are showing, by and large, a trend towards an increase in population. There were 110 such villages having 11% of the total rural population of Indiana in 1950. Their population increased about 38% and 15% during 1900-1950 and 1940-1950 respectively in comparison to an increase of 3.3% and 11.5% for the total rural population during the same periods. It is quite significant that 17 villages, not included in this study, of this size group in 1940, had crossed the 2,500 population mark in 1950, showing an increase of 58% over their population in 1940.

Out of 110 villages under consideration, 86 villages showed a net increase of 62% during 1900-1950 and of 19% between 1940-1950. As against this, there were only 24 villages which registered a net decline of 19.6% during 1900-1950, but a gain of 3.5% during 1940-1950.

An examination of the distributional pattern of the villages with a net increase (Fig. 1), shows that they are concentrated in five regions of Indiana, i.e., Northern, East Central, South Western, West Central and South Eastern Indiana. The villages with a higher rate of increase were found to be concentrated within the first two regions, while those with lower rate of increase were scattered all over the five regions (Fig. 2).

The villages with a net decrease between 1900-1950 (in no case more than 50%) ared istributed along the Ohio River in southern Indiana, two western counties of Sullivan and Clay and in east-central Indiana. In northern Indiana, there are a few villages scattered widely.

However, a consideration of net increase and decrease during a long interval of five decades does not give an idea of the actual trends in the population. On the basis of the decennial changes, these villages have been classified into six categories and the distribution of each category is discussed as follows:

I. Twenty-three villages with a continuous increase, which include:

  1. Four villages with an increase of 10% or more every decade.
  2. Thirteen villages with an increase of less than 10% during one or two intermediate decades.
  3. Six villages with an exceptional increase during 1940-1950.

  In their distribution, we find that they are mainly concentrated within North and East Central Indiana (Fig. 3).

Figure 1

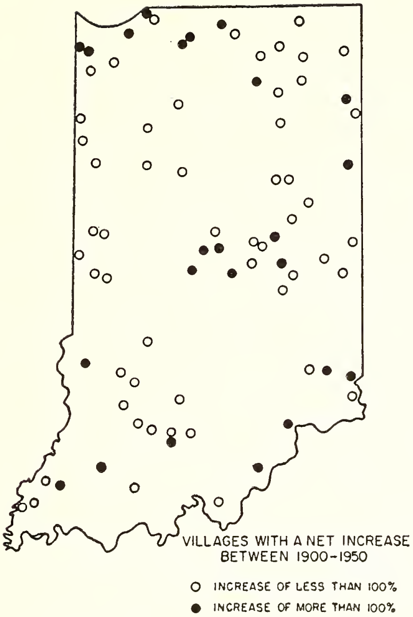

VILLAGES WITH A NET INCREASE BETWEEN 1900-1950
○ INCREASE OF LESS THAN 100%
● INCREASE OF MORE THAN 100%

Figure 2

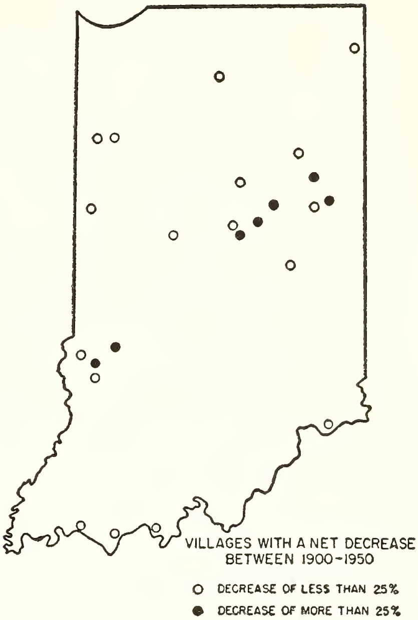

VILLAGES WITH A NET DECREASE BETWEEN 1900-1950
○ DECREASE OF LESS THAN 25%
● DECREASE OF MORE THAN 25%

Figure 3

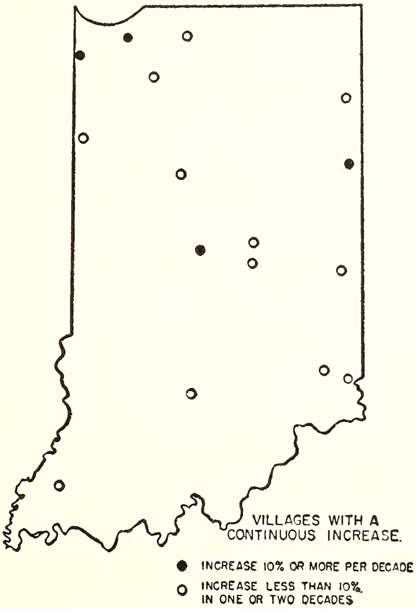
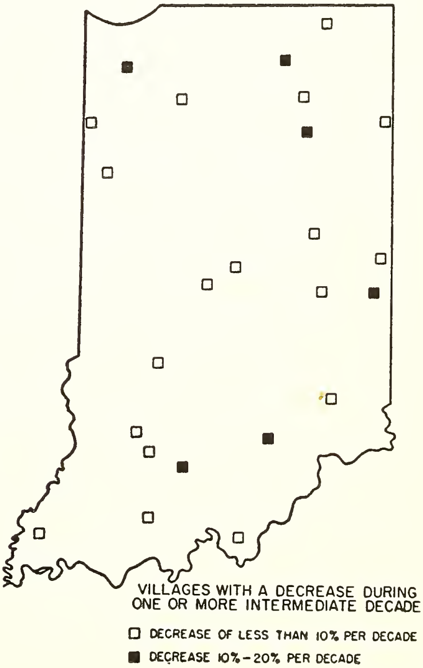

VILLAGES WITH A CONTINUOUS INCREASE.
● INCREASE 10% OR MORE PER DECADE
○ INCREASE LESS THAN 10% IN ONE OR TWO DECADES

Figure 4


VILLAGES WITH A DECREASE DURING ONE OR MORE INTERMEDIATE DECADE
☐ DECREASE OF LESS THAN 10% PER DECADE
■ DECREASE 10%-20% PER DECADE

II. Twenty-four villages with a decrease in population during one or more intermediate decades. The decennial decrease was less than 10% in the case of 18 villages and 10-20% in the case of six villages. These villages were scattered all over the state, without any particular regional pattern (Fig. 4).

III. Thirty-three villages with an earlier decrease but an increase since or after 1920.

This category is significant by virtue of the number of villages included, their distributional pattern and the year of peak population. In this category there are two classes of villages, i.e., 1) 20 villages with a peak population in 1950 and 2) 13 villages with a peak population in 1900. There is a concentration of these villages in East Central Indiana and Northern Indiana, with a minor concentration in the South Eastern Indiana. Significantly all the villages, except two, of this category in North Indiana had a peak population in 1950, while in East Central Indiana the villages with a peak population in 1900 and 1950 were equally divided in number. In South Eastern Indiana three out of four villages had a peak population in 1950 (Fig. 5).

IV. Twenty-five villages with no definite trend, that is with a fluctuating population. On the basis of their peak population, they come under three sub-classes:

1. Fifteen villages with a peak population between 1910-1940.
2. Six villages with a peak in 1900.
3. Four villages with a peak in 1950.

Their distribution is equally significant on account of their concentration in South West Indiana, west of a line between Warren County and Harrison County. Almost all of them reached a peak between 1910-1940. This is the only dominant category in South West Indiana. There are few scattered villages of this category in Northern and East Central Indiana, where they are outnumbered by the villages of the first three categories. Secondly, the villages in these regions had their peak in 1900 or 1950 (Fig. 6).

V. Four villages with an earlier increase but decrease since or after 1920. Although their population in 1950 was still above 1900 level, yet the trend towards decrease, started in the intermediate decades, does not seem to be encouraging. Three of these villages are located within South West Indiana and one in North Indiana.

VI. One village with a continuous decrease, except minor recovery during one intermediate decade. This village is also located in South Indiana.

This review brings out the following facts:

1. South West Indiana is a region of villages with unstable population showing a tendency towards decrease.

Figure 5

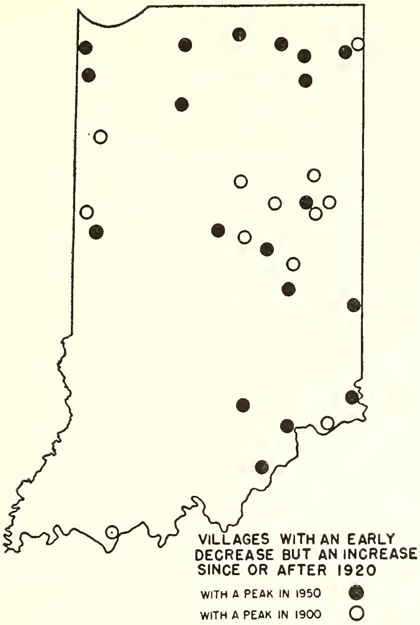

VILLAGES WITH AN EARLY DECREASE BUT AN INCREASE SINCE OR AFTER 1920
WITH A PEAK IN 1950 ●
WITH A PEAK IN 1900 ○

Figure 6

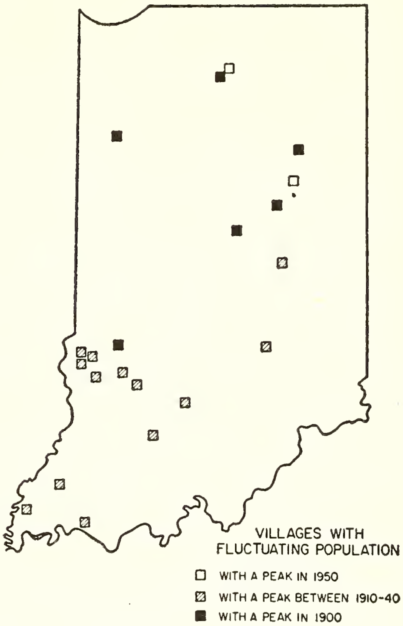
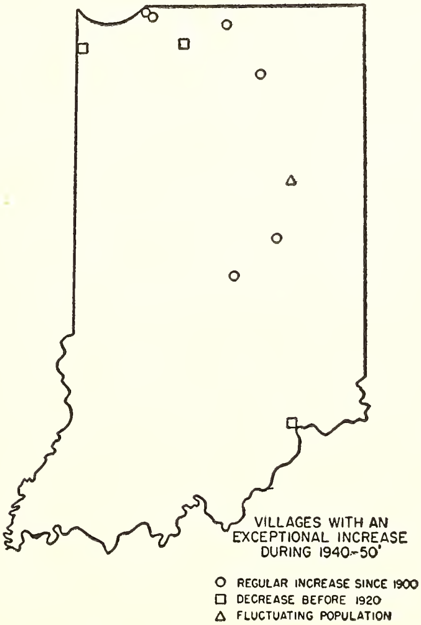

VILLAGES WITH FLUCTUATING POPULATION
☐ WITH A PEAK IN 1950
▨ WITH A PEAK BETWEEN 1910-40
■ WITH A PEAK IN 1900

Figure 7


VILLAGES WITH AN EXCEPTIONAL INCREASE DURING 1940-50'
○ REGULAR INCREASE SINCE 1900
☐ DECREASE BEFORE 1920
△ FLUCTUATING POPULATION

2. East Central Indiana is a region of villages showing trend towards increase particularly since or after 1920. However, some mixed tendencies were visible.

3. North Indiana has been a region of progressive villages since 1900.

4. South East Indiana is also a region of progressive villages.

An additional indication of the progressive nature of the villages in North Indiana is the concentration of all the villages with an exceptional growth (of more than 50%) during 1940-1950 (Fig. 7).

It is not within the scope of this review to go into the socio-economic and geographic causes for such trends and patterns of distribution, but an intensive study is highly desirable.

Manufactural Geography of Chicago Heights, Illinois[1]

ALFRED H. MEYER and PAUL F. MILLER

This study has for its objective a portrayal of the founding and growth of the industrial pattern of Chicago Heights in the framework of its regional setting and the coherent topographic and human factors of its site. Located twenty-five miles south of the Chicago Loop, eight miles south of the Chicago city limits, and just within the southern boundary of Cook County (Fig. 1), this relatively small-sized community of some 30,000 people[2] is distinguished by the magnitude of its manufacturing operations and by the enterprising coordinated civic agencies which have been effectively instrumental in developing a community pattern conducive to a sustained growth of industry. In contrast to many cities of its size in Illinois, it has a cosmopolitan population of a type usually identified with the largest municipalities in the United States. Its civic agencies have distinguished themselves in attacking the problem of integrating the social and economic life of the community in the rapidly expanding industrial pattern.

Chicago Heights has some four score manufactural industries, with an estimated value of manufactured products of 125 million dollars, of which approximately 65 million dollars represents value added by manufacturing. The labor force is estimated at 12,500—male 9,000; female 3,500.

Working through or in conjunction with some dozen or more commissions, committees, and other agencies are the so-called Committee for Chicago Heights, the Manufacturers Association, the Merchants Association, and the City Plan Commission, which recognizes the need of co-ordinating space requirements for all the various functions of the community. The Committee for Chicago Heights represents a cross section of banking, business, commercial, and other civic leadership, announcing its avowed purpose "to foster and further civic, industrial and commercial development of Chicago Heights." The Committee hopes to accomplish this purpose by "attracting new industry for increased payroll dollars and by solving local problems so that Chicago Heights is a better place in which to live" (1).

The Manufacturers Association is a composite one serving a number of local cities mostly contiguous to the Chicago Heights area. At present it includes such communities as Steger, Peotone, Monee, Matte-

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[1] This study is based on a field survey conducted by means of a questionnaire, personal interviews, and local field observations. It is the third of a series of manufactural studies in geography of the Calumet Region of Northwest Indiana-Northeast Illinois; the other two, those of LaPorte and Michigan City, Indiana, appear in volumes 64 and 65 of the *Proceedings*.

[2] Census of Population: 1950, U. S. Government, reports the figure 24,551.

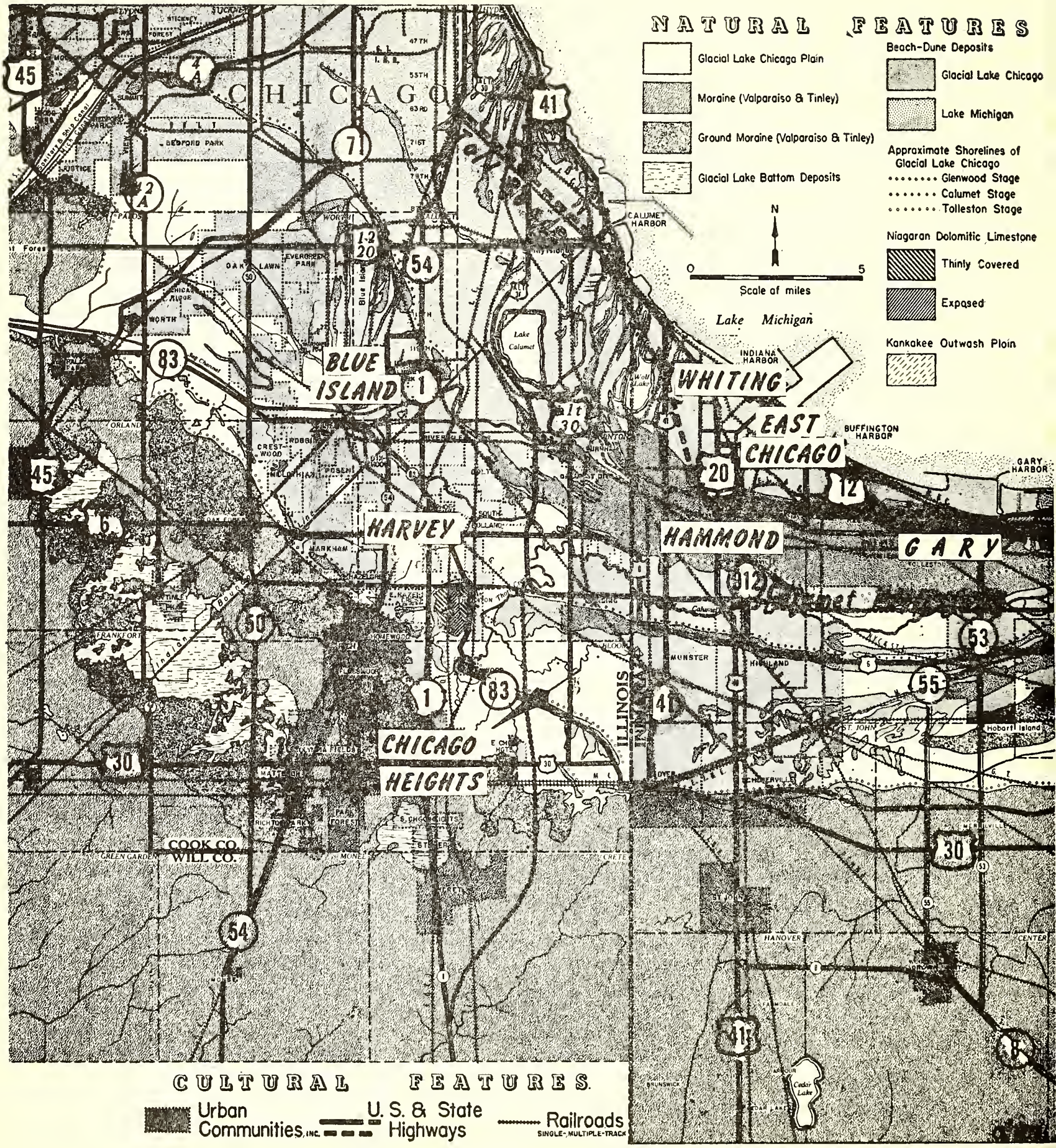


Fig. 1. The geographic setting of Chicago Heights in relation to its physiography, neighboring urban communities (including other industrial centers), the Calumet-Chicago metropolitan complex, and the major transportation pattern of the region.

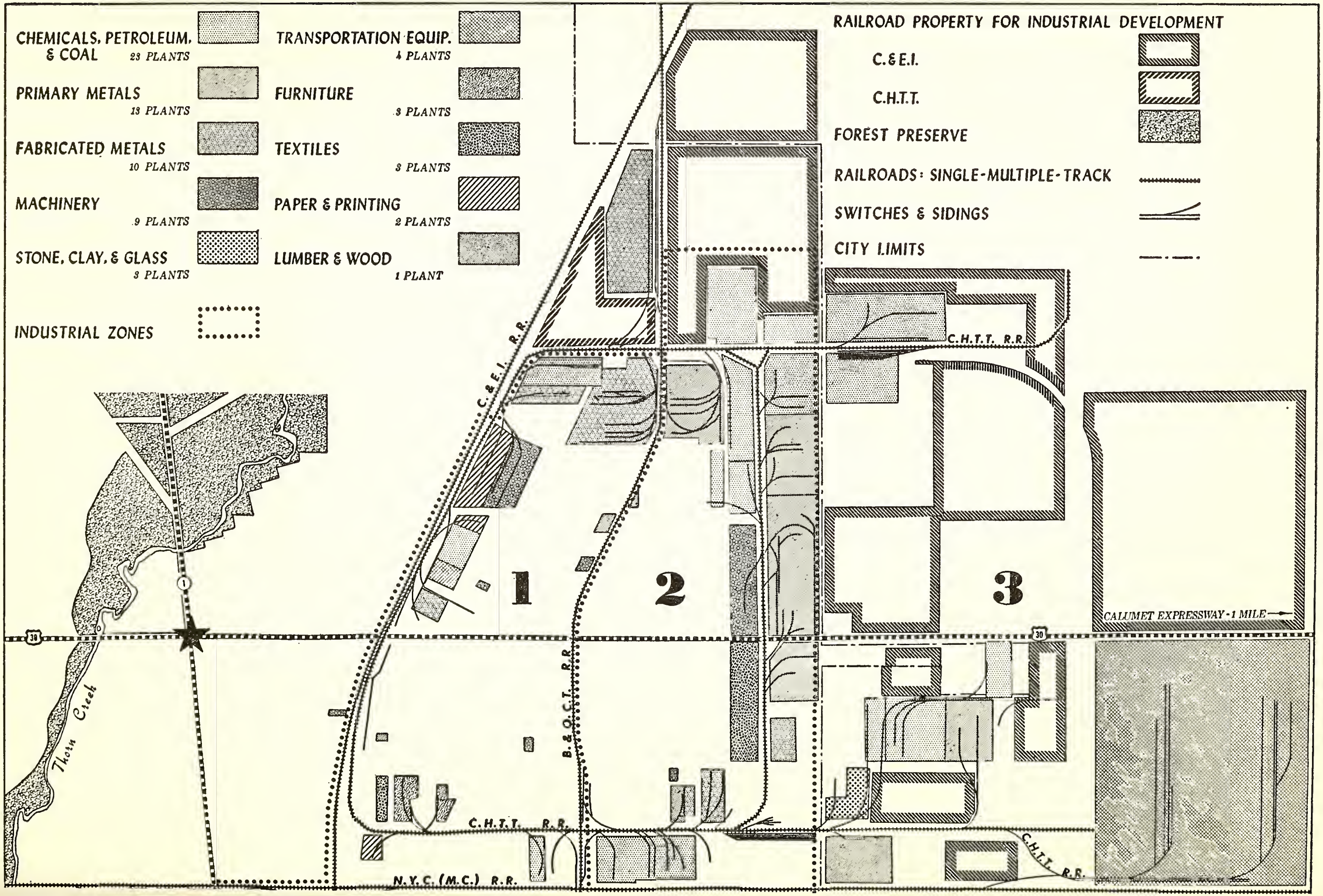
son, Homewood, and Thornton. All of these are contiguous to the Chicago Heights area with the exception of Peotone. Through interchange of information, the Association "attempts to increase manufacturing efficiency, inform members concerning impending legislative actions which might affect them, and through its public relations program to increase knowledge and understanding of local industry and assist in labor force training and recruitment" (2). Thus, whereas the Committee of Chicago Heights is credited with helping to bring industry into the area, such as the recent Ford Motor Company, Metisa Equipment Corporation, Pennsylvania Salt Manufacturing, among others, the Manufacturers Association helps industry realize its full potential.

Geo-Historical Factors

Chicago Heights is one of the "grove" communities of the western Calumet prairie, known originally as the Thorn Grove settlement. Pioneers in the middle nineteenth century migrating into the west end of the Calumet often sought out the more elevated and wooded sections rather than settling on the wetter prairie. Thorn Grove was one of these. Settlement in this grove was partly focused on the junction of two leading Indian trails in the west end of the Calumet region—the Sauk trail, now essentially US 30, and the old Hubbard's trace now essentially State Highway 1, partly known today as the Dixie Highway. (3). Sixteen settlers claiming squatter's rights settled here in 1838 under the Preemption Act. From the very beginning, this area had a rather cosmopolitan population, immigrants coming from France, Ireland, Scotland, Bohemia, Germany, Switzerland, and from many eastern states. Not only was the particular location inviting physiographically, but it had early advantages in attracting leaders from the Chicago area who became instrumental in developing land suited to industry. Thus "Charles H. Wacker, who was to become the first president of the Chicago Plan Commission, headed a group that purchased 1,260 acres in 1890. . . . Wacker attracted industry by offering free land and other concessions" (4).

Then in 1891 was formed the Chicago Heights Land Association which had for its specific objective the industrial development of approximately 4,000 acres of land in Bloom township. This association had two fixed policies: 1) "not to make the growth and prosperity of the city dependent upon any one line of industry," and 2) "to keep the factory district segregated from the residential part of the town, and as a result practically all the factories are located on the so-called 'East Side' "(5).

The Joliet and Northern Indiana Railroad ran a branch through Bloom in 1853, now known as the Michigan Central; and the Elgin, Joliet and eastern belt railroad was built in 1887. In the pioneer planning of this industrial community consideration was given to every facility that might attract industry. "One of the first facilities created was the Chicago Heights Terminal Transfer railroad for handling shipping to and from industrial plants and connecting with the many



CHEMICALS, PETROLEUM, & COAL 23 PLANTS
PRIMARY METALS 13 PLANTS
FABRICATED METALS 10 PLANTS
MACHINERY 9 PLANTS
STONE, CLAY, & GLASS 3 PLANTS
INDUSTRIAL ZONES
TRANSPORTATION EQUIP. 4 PLANTS
FURNITURE 3 PLANTS
TEXTILES 3 PLANTS
PAPER & PRINTING 2 PLANTS
LUMBER & WOOD 1 PLANT
RAILROAD PROPERTY FOR INDUSTRIAL DEVELOPMENT
C.&E.I.
C.H.T.T.
FOREST PRESERVE
RAILROADS: SINGLE-MULTIPLE-TRACK
SWITCHES & SIDINGS
CITY LIMITS
C.&E.I. R.R.
C.H.T.T. R.R.
B.&O.C.T. R.R.
N.Y.C. (M.C.) R.R.
CALUMET EXPRESSWAY-1 MILE
30
1
1
2
3
Thorn Creek

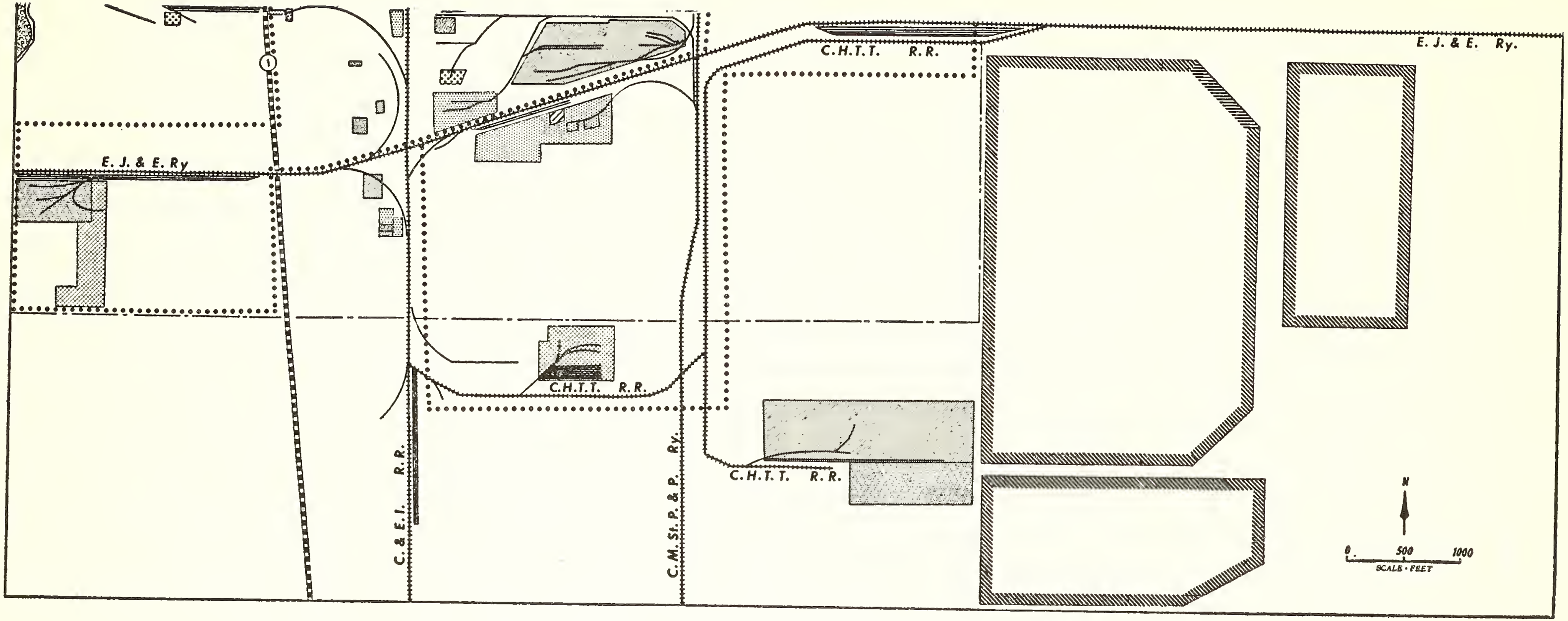


Fig. 2. The classified manufactural pattern of Chicago Heights in the geographic framework of transportation and switching service, railroad land available for industrial development, and the progressive general zonal shifting of industrial occupance from west to east (zones 1, 2, 3).

railway lines serving Chicagoland. It is important to note that this transportation advantage was the outstanding feature that attracted the first batch of industries to the area" (6).

Splendid transportation facilities, close rail connection with the coal fields of Illinois and Indiana, low water taxes, were other features which attracted industry.

A year by year chronological listing of the appearance of the various industries establishing themselves in the Chicago Heights area, as revealed in a brochure issued by the Committee for Chicago Heights, lends itself to some interesting observations on the growth of the industrial structure.

The first major industries in Chicago Heights started to be established in 1890 (American Manganese Steel Division and the American Brake Shoe Company); 1893 (Inland Steel Company); and 1896 (Victor Chemical Works). This was followed by a progressively increasing number of industries established throughout the years from 1900 to the present (1956). The present-day manufacturing plant pattern appears in Fig. 2. Three plants appeared in 1900; 1 (1902); 3 (1904); 1 each (1906, 1907); 2 (1908); 1 each (1909, 1915, 1916, 1917, 1918, 1919); 2 each (1920, 1921); 1 (1923); 2 each (1925, 1928); 1 each (1932, 1937); 3 each (1938, 1940, 1941); 1 (1943); 3 each (1945, 1946); 1 (1947); 3 (1948); 1 (1949); 6 (1950); 2 (1951); 1 each (1952, 1954); 2 (1955); 3 (1956).

The growth pattern of industrial establishments may be related to four stages: The first period of development up to 1909 is identified with the program of the Chicago Heights Land Association. The second, from approximately 1915 to 1920 is related to the efforts of the Chicago Heights Manufacturers Association. The third, from 1921 to 1937, is reflective of the financial depression. New impetus in industrial development is recognized as starting about 1938 and continuing down to the present. These chronologic data, reduced to a chorographic base of three zones, as incorporated in Figure 2, point up the general progress of manufactural pattern development from west to east. In the original core (zone 1) the majority of industries (nearly 70%) was established by 1920. In the second zone 75% of the industries had been started after 1920. In the third zone the outlying section on the east end of the city, much of which is outside of the city limits, includes industries nearly all of which were established since 1931.[1]

Regional Considerations

Chicago Heights is part of the Chicago-Calumet region, physiographically, commercially, and industrially.

Thorn Creek, which drains the Chicago Heights area empties into the Little Calumet River which, in its course westward, joins the Calumet-Sag barge channel. The northeast section of Chicago Heights along Thorn Creek is part of the glacial lake bottom laid down by Old Lake Chicago. Rising to the center is the Tinley ground moraine and on the south the Tinley terminal moraine. This higher and better-drained site compared with the poorly-drained lake plain areas to the north was credited in early days as an influential factor in pioneer settlement and subsequent industrial development. Geomorphologically, it is significant to note that the elevation of site is also identified with a rise in bedrock contour, the Niagaran dolomitic limestone in this district coming within 25 feet or less of the surface (Fig. 3). This sub-surface structure came to be recognized as a decidedly beneficial factor in establishing secure footings for foundations, particularly by the more recent establishments of the heavy industrial type. Vicinal description of this rock elevation appears in a bulletin of the Illinois State Geological Survey as follows:

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[1] Based on compilations by Mr. Donald Killmer.

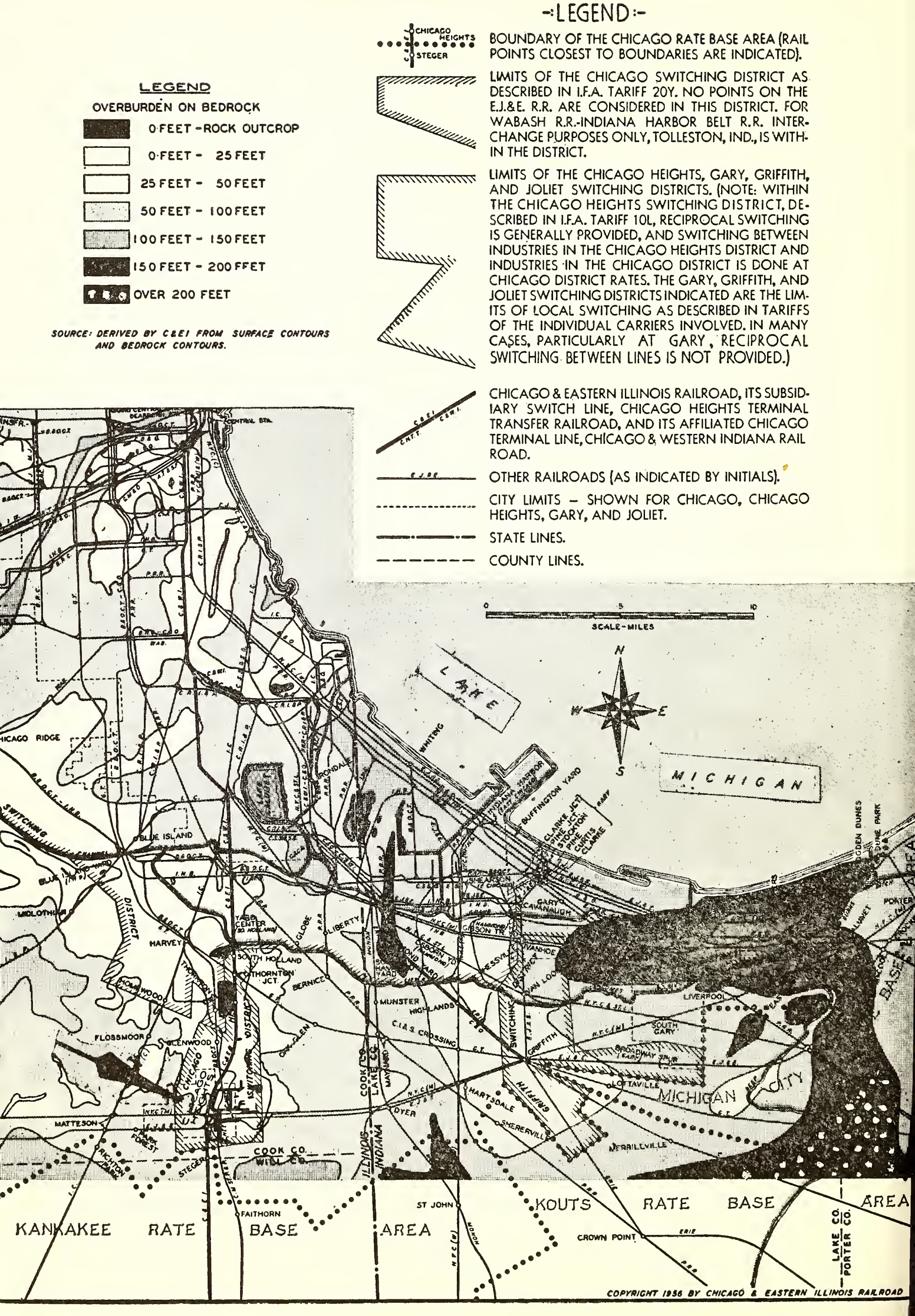
"A rock hill, partially buried by glacial drift so that only its northeastern and eastern slopes crop out, occurs in East Chicago Heights near the intersection of Cottage Grove Avenue and Lincoln Highway about four miles south and one mile east of the Thornton klint. It rises rather steeply from the highest level of the lake plain on the north and has a relief of 25 to 30 feet. In an old quarry along Cottage Grove Avenue there are northward-dipping reef beds" (7).

Such close proximity of limestone to the surface suggests profitable limestone quarrying operations, and this potential has not been overlooked; however, as Mr. Arthur Longini, chief economist of the C. & E. I. R. R., has pointed out, industrial and transportational revenues which may accrue from such development may very well be offset by liabilities associated with quarrying, particularly the eventual precautions which have to be taken in preventing trespass into an abandoned quarry area.

Occupying the west end of the Calumet region, and only a few miles from Chicago, Chicago Heights has commonly been considered a part of commuter and commercial metropolitan Chicago. For one thing, it shares with Chicago a common airport; however most of the residents of the city work in the immediate area and not Chicago, and so, as indicated by Mr. W. W. Thorsness, Executive Secretary of the Manufacturers Association, the city definitely is not considered a commuter "bedroom city" such as Park Forest, Homewood, and Flossmoor. Chicago Heights has also been commonly recognized as regionally a part of the Chicago Industrial area; however, here again Mr. Thorsness, feels that Chicago Heights, despite its proximity to Chicago, "is actually a separate and distinct industrial area," emphasized by the fact that "we are separated from Chicago by another industrial area, namely Harvey, which is eight miles north of Chicago Heights."

A regional factor of great significance to industrialists is related to advantageous trade rates. "Though Chicago Heights is not a part of the Chicago switching district, it has been granted the same freight rates and so has advantages over all other communities not in the Chicago switching district which do not share the privilege of intra-rate switching at the Chicago switching district rates." (Fig. 3).

Since the tax rates in Cook County are higher than in adjacent Will County on the south, Chicago Heights, just inside the southern boundary of Cook County, experiences here a disadvantage; however this



-:LEGEND:-

BOUNDARY OF THE CHICAGO RATE BASE AREA (RAIL POINTS CLOSEST TO BOUNDARIES ARE INDICATED).

LIMITS OF THE CHICAGO SWITCHING DISTRICT AS DESCRIBED IN I.F.A. TARIFF 20Y. NO POINTS ON THE E.J.&E. R.R. ARE CONSIDERED IN THIS DISTRICT. FOR WABASH R.R.-INDIANA HARBOR BELT R.R. INTERCHANGE PURPOSES ONLY, TOLLESTON, IND., IS WITHIN THE DISTRICT.

LIMITS OF THE CHICAGO HEIGHTS, GARY, GRIFFITH, AND JOLIET SWITCHING DISTRICTS. (NOTE: WITHIN THE CHICAGO HEIGHTS SWITCHING DISTRICT, DESCRIBED IN I.F.A. TARIFF 10L, RECIPROCAL SWITCHING IS GENERALLY PROVIDED, AND SWITCHING BETWEEN INDUSTRIES IN THE CHICAGO HEIGHTS DISTRICT AND INDUSTRIES IN THE CHICAGO DISTRICT IS DONE AT CHICAGO DISTRICT RATES. THE GARY, GRIFFITH, AND JOLIET SWITCHING DISTRICTS INDICATED ARE THE LIMITS OF LOCAL SWITCHING AS DESCRIBED IN TARIFFS OF THE INDIVIDUAL CARRIERS INVOLVED. IN MANY CASES, PARTICULARLY AT GARY, RECIPROCAL SWITCHING BETWEEN LINES IS NOT PROVIDED.)

CHICAGO & EASTERN ILLINOIS RAILROAD, ITS SUBSIDIARY SWITCH LINE, CHICAGO HEIGHTS TERMINAL TRANSFER RAILROAD, AND ITS AFFILIATED CHICAGO TERMINAL LINE, CHICAGO & WESTERN INDIANA RAIL ROAD.

OTHER RAILROADS (AS INDICATED BY INITIALS).

CITY LIMITS – SHOWN FOR CHICAGO, CHICAGO HEIGHTS, GARY, AND JOLIET.

STATE LINES.

COUNTY LINES.

LEGEND

OVERBURDEN ON BEDROCK

■ 0 FEET – ROCK OUTCROP

☐ 0 FEET – 25 FEET

☐ 25 FEET – 50 FEET

░ 50 FEET – 100 FEET

▒ 100 FEET – 150 FEET

▓ 150 FEET – 200 FEET

● OVER 200 FEET

SOURCE: DERIVED BY C&EI FROM SURFACE CONTOURS AND BEDROCK CONTOURS.

COPYRIGHT 1956 BY CHICAGO & EASTERN ILLINOIS RAILROAD is said to be offset by the advantage of having an adequate sanitary disposal plant and enjoying freight rates not being shared by adjacent Will County communities. Moreover, the local township (Bloom) has an excellent high school which not only prepares the students for college, but also in some instances through its industrial department prepares a student for employment in industry upon completion of his high school term.

A certain type of regionality also exists with reference to the geographic area served by the Manufacturers Association, as indicated by the list of community members who share a common denominator of industrial interests. Generally speaking, this represents a contiguous area. Other communities may become members of the organization at the discretion of the Board of Directors even though such communities may not necessarily be in contact with the larger area (ex∴Peotone).

Other regional associations of significance as, for example, those dealing with transportation both by water and land, will be considered under the heading of Transportation.

Evaluation of Locative Factors as Based on Questionnaire

The interview data supplied for our questionnaire by the industrialists of Chicago Heights indicate considerable awareness of the significance of locative factors in the establishment of industry. This, no doubt, is due in large measure to the alert and aggressive Manufacturers Association, the Committee on Chicago Heights, and the City Planning Commission, previously mentioned, which effectively co-ordinate their efforts in eploring and exploiting every opportunity to realize the community's full industrial potential. Only seven interviewees (15%) were unaware of any specific factor or combination of factors, instrumental in influencing management to locate in this region, or on the particular site occupied by the establishment. The questionnaire on this point reads as follows: "Were locational advantages considered in selecting the site as regards any geographic facility, economic factor, or political consideration"? Answers to this question were sought both with reference to the general area of Chicago Heights as well as the particular site selected in the city. The interviewee was then asked to explain and evaluate the relative importance of each influential locative factor. From these data we derive the following categorical observations in relative order of frequency of notation.

Regional Relations—Over half of the respondents indicate regionality to be a leading factor in industrial location. In terms of general

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Fig. 3. A dual purpose map, featuring 1) regional differentiation in bedrock overburden, and 2) the geographic relation of the freight rate structure area of Chicago Heights to the Chicago Rate Base Area. As concerns the bedrock overburden, note the thin overburden (0-25 feet) in the Chicago Heights area which facilitates stable foundation construction, especially essential for the numerous heavy industries of the area. In relation to the cartographic feature, note the favored switching facility as described in the legend. (Reproduction of this copyrighted map is by special permission.)

regional considerations we note the following observations: centrally located; centrally located to the best industrial cities of the areas; near the railroad lines and the railroad center of the U. S. A.; proximity to Chicago; close to Chicago and east Chicago; near southside plants; steel mills nearby; near residential area.

Labor regional relations were emphasized by some eight respondents (17%) in terms of local availability or regional proximity: away from the congested and immediately competitive labor market; labor cost at reasonable employment scales.

Regional market considerations were on a par with regional labor evaluations. Representative were the following: We located in Chicago Heights to be closer to the trade; Chicago offered a good market for goods; we were here close to big factories that could use our services.

Regional relations as respects raw materials seemingly was a less significant factor. Only three respondents expressed themselves with reference to accessibility of steel and other raw material.

Transportation—This is the leading single reported locative consideration, about forty percent of the respondents noting this factor. Representative (and usually duplicative) comments of this group follow: Accessibility to transportation by raid, C. & E. I. and truck (US 30); railroad facilities of Chicago Heights very good, and especially at this particular spot in the city; are closer here to the railroads and highways (transportation network); have a spare track (railroad siding) away from the congested area outside the city; [advantageous] Chicago shipping rates.

Space—Understandably, adequacy in quantity and quality of site for the placement of buildings constitutes a leading category in locational consideration, almost identical in rank with transportation. Some eighteen industries, or approximately thirty-eight percent, gave focal emphasis to this environmental factor. Representative statements follow: Space was important; the only available place to go was Chicago Heights; land was plentiful; land was for sale and was reasonable compared to Chicago prices; land was for sale and land was large enough to build the amount of buildings needed; we were able to rent space reasonably in Chicago Heights; particular site was chosen because of space and railroad facilities; found land available outside of city limits; moved our plant in order to get more space; when we built we were the only plant in area; we had here opportunity to get away from congested area outside city limits.

Previous Building—Quite a number of firms (13), or about twenty-eight percent, indicated that they were influenced in their site location by the fact that some building previously existed there. Thus the following rather common expressions: This company purchased its sight from a previous foundry; the quarters were available; the particular site was chosen because the land and buildings were already available; we found a cheap building and land; the physical plant was already here; bought out another company; the building was vacant; space was available in a rented building.

Utilities—It is interesting to note that only two of the respondents out of the entire group mentioned utilities in this connection. The importance to this rapidly growing industrial community of ample supply of water, adequate drainage, and sewerage, along with other utilities, is not underevaluated, however, as is indicated elsewhere in this survey.

Miscellaneous—Individual firms enumerated other diverse reasons for locating in Chicago Heights: Found Chicago Heights presented the only available space suitable, after having had to move out of Chicago; this company was in a process of decentralization and was also in search of another labor market; this is the only tool and dye shop in town; land was large enough to build the amount of buildings needed, and other industry was here already; close to Victor Chemical Company and Blockson Chemical Company and various suppliers in area; my home is in Monee, and as this is a sideline, I wanted it to be near.

Areal Labor

Industrial Chicago Heights employs approximately 10,500 persons, 3,000 (28.6%) of whom are employed at the recently opened Ford stamping plant. With the addition of this one plant, the classification of "fabricated metal" becomes most important in terms of total employed. The classifications of chemical-petroleum-coal and primary metals formerly occupying first and second rank respectively, now are relegated to second and third place.

The 1950 U. S. census listed 4,836 people employed by local manufacturing concerns. In contrast with this are the figures of 7,500 for early 1956 and 10,500 of today. One-fifth (20%) of the employed are female. There is local sentiment for the establishment of types of factories which would utilize a higher proportion of women, especially Negro. The accelerated industrialization at the close of the last century was accomplished in large measure by immigrant laborers from southern and eastern Europe, as reflected by the hundreds of Italian and Polish names in the community. This mass migration of Europeans to America was drastically curtailed by the immigration laws of 1920. To fill this partial labor vacuum, Negroes and Mexicans settled in the city, so that in 1950, they composed 16.8 percent of the population.

Since the second World War the location and the relocation of industry in peripheral Chicago progressed on a large scale. This trend has caused a relative scarcity of much-needed labor in such suburban areas—more so than in most of Chicago proper.

Ford Motor Company expects to add 1,000 employees to the local plant in the near future. This prospect plus the anticipated location of new industry will serve to make Chicago Heights a large labor market. Two sources of labor will supply the local labor needs. Firstly, Chicago Heights will continue to participate in the rapid population increase being experienced in suburban Cook County. Secondly, the increased labor mobility afforded by new expressways will contribute to the community's regional labor market. As industries locate here and expand, the partial labor vacuum will require more and more persons from the surrounding area. The approximate radial dimensions of the major labor tributary area is twenty miles. Area more distant than twenty miles generates 2.6% of the total labor force.

The following table categorizes in terms of distance the source of the total employed in Chicago Heights. It is noteworthy that 41.4% of employees live outside of the city limits (2). A large part of this non-city labor comes from the rural land to the south of Chicago Heights. Situated at the northern edge of the corn belt, local industry can draw upon farmers and the non-industrialized farm town. Not only is this a supply of good labor, but such a rural supply tends to moderate the local wage rates.

TABLE

Percent of total employed	Distance of origin
	Within 5 miles
58.6%	a) inside city limits
19.7	b) outside city limits
10.1	5-9 miles
9.0	10-19 miles
1.3	20-29 miles
.9	30-39 miles
.3	40-59 miles
.1	60 miles and more

The Transportation Pattern

With a manufactural structure dominated by primary metals, fabricated metals, and chemicals, Chicago Heights industry is based upon a dense local rail net. The six railroads servicing local industry give excellent service in all directions, especially to the Chicago-Calumet complex for the in-movement of bulk raw and semi-processed goods.

Since Chicago Heights is located at the first hub of rail lines southwest of Chicago proper, local industry is proximal to both the belt lines outside of Chicago, and the dense trackage of Chicago itself. The following table outlines the freight rail service locally available. Of the fifty industries serviced by rail, all but eight are served by the Chicago Heights Terminal Transfer Railroad (Fig. 4).

Geographically viewed, Chicago Heights is outside of the Chicago Switching District. The location of the Indiana Harbor Belt Line

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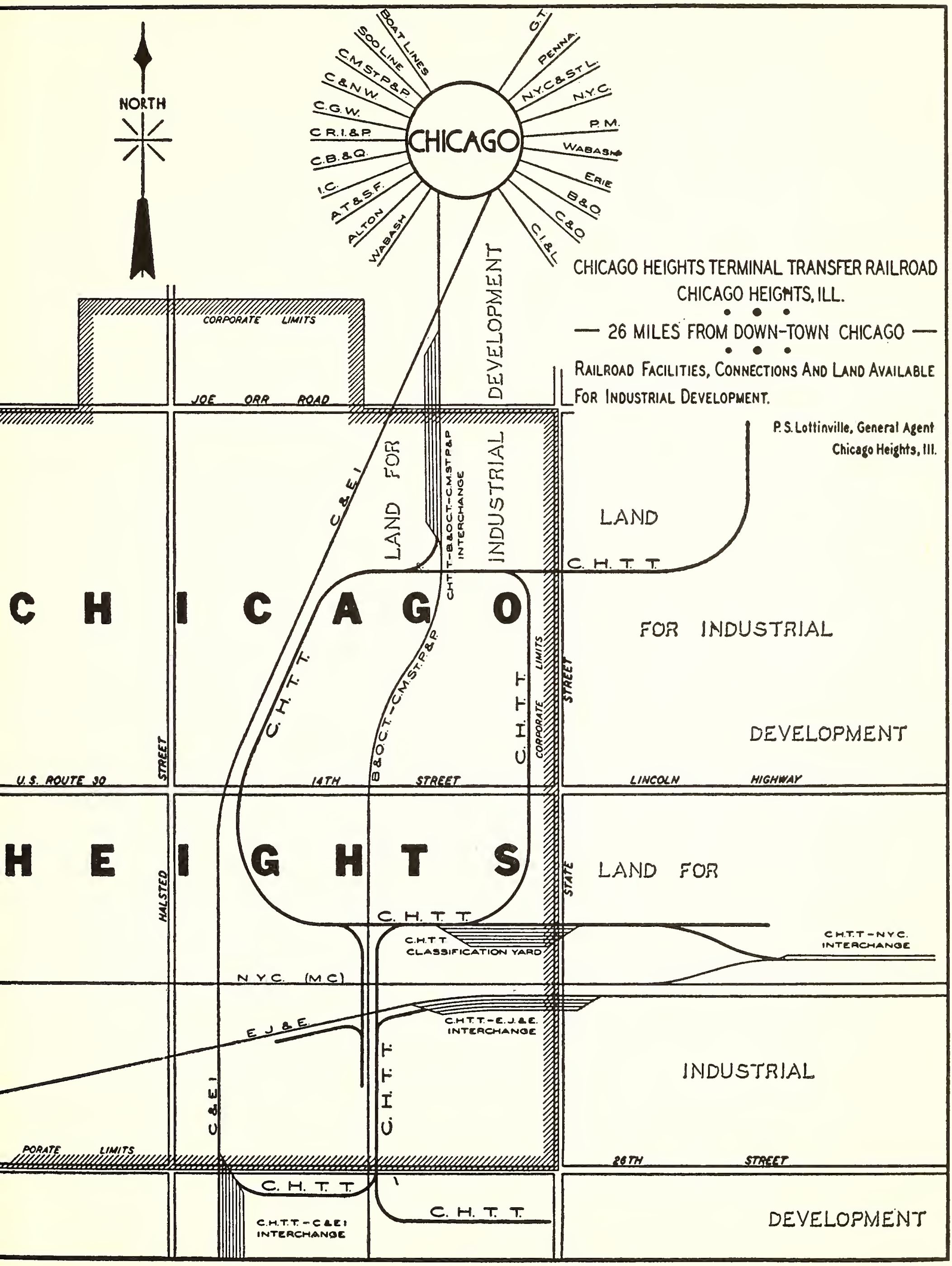
Fig. 4. One of the major rail advantages of Chicago Heights is the transfer facility provided by the C.H.T.T.R.R. as shown in this special feature map. Comparison with Fig. 2 reveals how this pattern fits into the general transportation and industrial patterns. It is noteworthy that of the fifty industries served by rail, all but eight are served by this transfer facility.



CHICAGO HEIGHTS TERMINAL TRANSFER RAILROAD
CHICAGO HEIGHTS, ILL.

• • •

— 26 MILES FROM DOWN-TOWN CHICAGO —

• • •

Railroad Facilities, Connections And Land Available For Industrial Development.

P. S. Lottinville, General Agent
Chicago Heights, Ill.

TABLE

Name of Railroad	Direction of Service	Nature of Service
Chicago and Eastern Illinois Railroad	North-South	Most of north-south traffic
Baltimore and Ohio Terminal Railroad	North-South	Inner Belt Line Service
Chicago, Milwaukee, St. Paul and Pacific	North-South	Chicago-Milwaukee with S. Indiana
New York Central (Michigan Central)	East-West	Most of non-local E-W traffic
Elgin, Joliet and Eastern Railway	East-West	Steel traffic. Outer Belt Line Service
Chicago Heights Terminal Transfer R. R.	N. E.-S. W., and local	Connecting with Chicago Switching District

demarcates the extent of the District, and Chicago Heights lies without this delineated region; however, as the result of a court case, Chicago Heights, in the Chicago Heights Switching District, was granted the same rates as the Chicago District (Fig. 3). With this favorable rate structure, it can successfully compete with other suburban areas and even with Chicago for industries which need both cheap bulk transportation and large tracts of land; moreover, as pointed out by Mr. Thorsness, "Our local intra-industry switching rate is substantially lower than that which applies between industries in the Chicago Switching District.

Over 3,000 loaded freight cars are handled monthly. The average of six months in 1955-56 indicates that approximately 30 percent are loaded with local manufacture, and 70 percent bring in materials to be manufactured. Approximately 80 percent more industries use predominantly rail for shipping in than in shipping out. In spite of the heavy reliance upon rails, twelve industries reported an increasing use of trucks.

The city's location is strategic not only in reference to rail transportation, but also in terms of highway circulation and developments. Astride the intersection of the Dixie and Lincoln highways, Chicago Heights' transportational position is enhanced by the recent construction of the Calumet Expressway and the anticipated development of an Indiana to Wisconsin Expressway, six miles north of the city.

Utilizing the road net are several local trucking lines and more than 150 line haul trucking companies with rights to handle ingoing and outgoing freight.

Ten miles to the north is the Calumet Harbor development. Because of local heavy industry and good transportation connections, Chicago Heights can be expected to participate in the beneficial effects of the port's future expanded traffic, most likely in cheaper bulk commodities.

Geographic Origin of Raw Materials

The general sources of the major raw and processed materials can be rather easily outlined. Of the twelve plants in the primary metals classification, all but one use scrap; and, therefore, are more market-oriented. Most of the scrap is railway scrap, so that these industries have a good source of materials in Chicago, the railroad center of the United States. Only Columbia Steel, which electrically produces a high-grade tool steel, uses ore. The chemical plants have good bulk transportation for the movement of petro-chemicals from the south-central states, and they are in close proximity to the chemical concerns of the Greater Chicago region. Wood is procured from the Northwest, Canada, and the Southeast. Textiles and textile materials come almost entirely from the Southeast. Miscellaneous materials come from a wide diversity of sources, but the Chicago Region itself is a major source of both the common bulk commodities and the more diversified materials.

Regional Markets

Being a mature industrial community, Chicago Heights ships manufactures throughout the United States. Several of the local industries are branch plants, however, and were located to serve a regional market. A large part of local industry, then, serves the Midwest, especially that area economically tributary to Chicago. Agricultural chemicals are in close transportational proximity to the large fertilizer user—the Corn Belt. At the same time, the non-agricultural chemicals are part of the Chicago Region, with its diversified demand. The several asphalt product plants, based on a local tradition of building supplies, are near to an area which is experiencing a building boom, including not only south Cook County, but the entire Chicago-Calumet region.

Local Utilities

An ample supply of water is gotten from shallow wells on the west side of the city. Twenty percent of the interviewed industries made negative comment about the quality of the water supply (hardness, odor, taste). Because of this, in part, many plants have their own wells.

Chicago Heights is in the Bloom Township Sanitary District, which also serves Park Forest and South Chicago Heights. In 1956 the capacity of the treatment plant was doubled so that it could service 75,000 people. Since the Sanitary District now includes 60,000 people, the treatment plant will most likely be operating at capacity in a very few years.

Availability of excellent electric power was a major consideration in the location of the Ford stamping plant. Commonwealth Edison operates a large generating plant near the Illinois-Indiana line at Lake Michigan. This company helped to locate the Ford plant.

Some Self-Recognized Industrial Problems

Problems of industry, like locative factors, can often best be explored by specific reference to original statements of the industrialists themselves. Such procedure as the following, then, has certain advantages: 1) It substitutes objective reality of facts and evaluations for subjective thinking and rationalization based on purely environmental considerations. 2) And since in many cases, time and circumstances vary considerably from industry to industry, it is often difficult to categorize or regionalize differences among them—a problem of a particular industry may not be geographically related to the area at all. 3) Such procedure helps to distinguish factors essentially geographic from those which are not inherently geographic.

More than half of the respondents recognized some particular problem identified with its type of industry or otherwise as related to this particular region. Five respondents mentioned the cost of transportation or other transportation problems, such as: raw materials from a long way, making service slow; high freight rates; raw materials obtained from areas having natural resources; shipment appreciably affected by cross freight. Four mentioned competitive problems: competition is not unionized; competition with southern mills; cheaper labor down there; have to pay low wages here, but they are higher wages for this type of industry.

Three of the respondents mentioned labor troubles: difficulty of getting skilled help; labor problems in the form of strikes; wage conditions.

Comments on miscellaneous items included the following: Our firm follows the business cycle; our business follows the general trend of construction; we have to have our plant near the market; our markets are particularly affected by the purchasing power of railroads and heavy industries; our business affected by trends of the auto industry; two comments on odor problems.

About one-fourth of the industries stated they had evolved a particular plan for solving the problems just mentioned. Trucking appears to be one of the major solutions of the transportation problem. As pointed out by one respondent, "We hope we are equal to Chicago producers now that trucks are used." Another, "We save considerable money by the use of trucks." And still another points out that cost and better service may be effected by pooling cars. Better trucking service is also being sought from truck lines that serve Chicago but do not pick up freight in Chicago Heights.

Plant location, or relocation, or the establishment of branch plants appears to be the solution for some industrial problem; for example, "putting plants where the markets are."

Solutions to some of the other problems are suggested by some of the following remarks: diversification of products; rising control methods; writing to congressmen and the aluminum and smelting associations; unionizing competitors; developing new technical approaches.

With respect to site conditions the question was asked, "Do you recognize any industrial land-use problems in your area with respect to the quality and quantity of land available for industry?" Ten reported some type of site-expansion problem by such comments as: no expansion room; rather hard to find suitable space since a railroad owns the land; can't expand on the present site; not enough land; railroad on two sides of city streets and manufacturing; plant site hemmed in by other industries; new housing development encroaching on land which might otherwise be used for expansion. It is noted that during the war there were complaints about noise from hammers in a particular establishment. One industry noted the lack of good water.

Restrictive and Remedial Measures

To the query, "What legislative restrictive measures, if any, add to the cost of operating expenses?" only twenty-four had any comments to make. The one important factor stressed was taxes: normal taxes, state unemployment taxes, health and accident taxes; corporation taxes; sales taxes; sales taxes; sales taxes; sales taxes and all other state and city taxes that are inflicted on tax-paying people; sales tax and royalties; tax on sales and all others raising prices; only the common tax which industry has; sales tax.

Other diverse restrictive measures were noted as follows: state laws with respect to age of employees; some local measures and trucking laws; control of dust and fumes by local and state authorities; very reasonable and only minor safety precautions; safety devices; social welfare; general trends in labor; tax laws and bookkeeping affected by this.

Question: Can your community and your industry, in your judgment, effectively share joint responsibility in eliminating geographic maladjustments; Thirty-two indicated a possibility of using some agency in this direction. Eight of them specifically mentioned the various civic organizations or city ordinances: Manufacturers Association and City Planners; we work with the Chicago Heights Manufacturers Association; we work with the Chicago Heights Manufacturers Association; we work through the Chicago Heights Manufacturers Association; we work with the Committe for Chicago Heights; we are leaders in the Committee for Chicago Heights; two others speak of general community effort.

Question: What local, regional, national, or foreign geographic data do you consider essential in helping understand and solve problems related to your type of industry? Only some dozen firms saw fit to respond to this question. About ten indicated that certain survey studies of their own were being made: population surveys; data on expected location of building booms; the use of maps and charts; population statistics and school statistics; sales tax and royalties; data on car and automobile, and truck sales from one year to the next as to our own production; we use catalogues to send to dealers and that is all.

Question: Are local and regional zoning and geographic planning ordinances adequate to meet all the needs of your plant for present operation? For anticipated future expansion? Of the forty who commented on this point, thirty-six indicated apparent adequacy for present and future available land for industry. Typical comments follow: yes, we can expand in an easterly direction; we own enough land for future development and expansion in this area; zoning is adequate. Some two respondents responded with qualifications as to adequacy. Present facilities adequate but not for the future. Several indicated inadequacy of expansion possibility as follows: they don't consider us at all; our area is zoned only for agriculture; our future expansion limited by city housing development. Several indicated they were outside the city limits and in several instances added they were outside of the zoning regulation area.

Planning and Zoning

It is obvious that in a modern manufacturing community such as Chicago Heights the availability of suitable industrial sites and favorable transportation facilities depends upon adequate planning and zoning regulations. Thus we observe from a recent news letter of the Michigan Department of Economic Development, the following observations: "The community must show that it really is prepared for industry, that it carries on sound planning and has good zoning." Due to the recency of the adoption of the comprehensive City Plan for Chicago Heights, few industrialists seemingly were prepared at the time of our interviews to make specific comments on how the new city zoning and planning regulations affected their particular plant interest so far as location and operation are concerned; however, an examination of the comprehensive City Plan brochure, issued by the Chicago Heights Plan Commission, March, 1955, reveals a definite perception of local areal land-use interest and planning intelligence. Besides the zoning map reproduced herewith (Fig. 5), the brochure includes maps featuring the following: generalized land-use patterns; thoroughfare plan; community facilities plan. These maps illustrate the interrelationships existing between the various physical and cultural elements of the community and systematic and coordinate planning for the varied city functions.

As far as industry itself is concerned, several factors are particularly noteworthy: 1) The very large amount of land allocated to industry. Some of this is within the city limits; a greater amount is outside of the city limits and subject to county planning jurisdiction. 2) The large amount of land now owned by the C. and E. I. Railroad held for industrial use. 3) The exceptionally large area zoned for heavy industry. This is well-situated geographically in relation to the number of coherent factors. We quote: "Heavy industry is concentrated on the east side of the city where it is served by several railroads and major streets. It is anticipated that the area between State Street and Cottage Grove Avenue will eventually be annexed to the city and developed as an extension to this industrial district. Because the prevailing winds are from the southwest, any possible adverse influence

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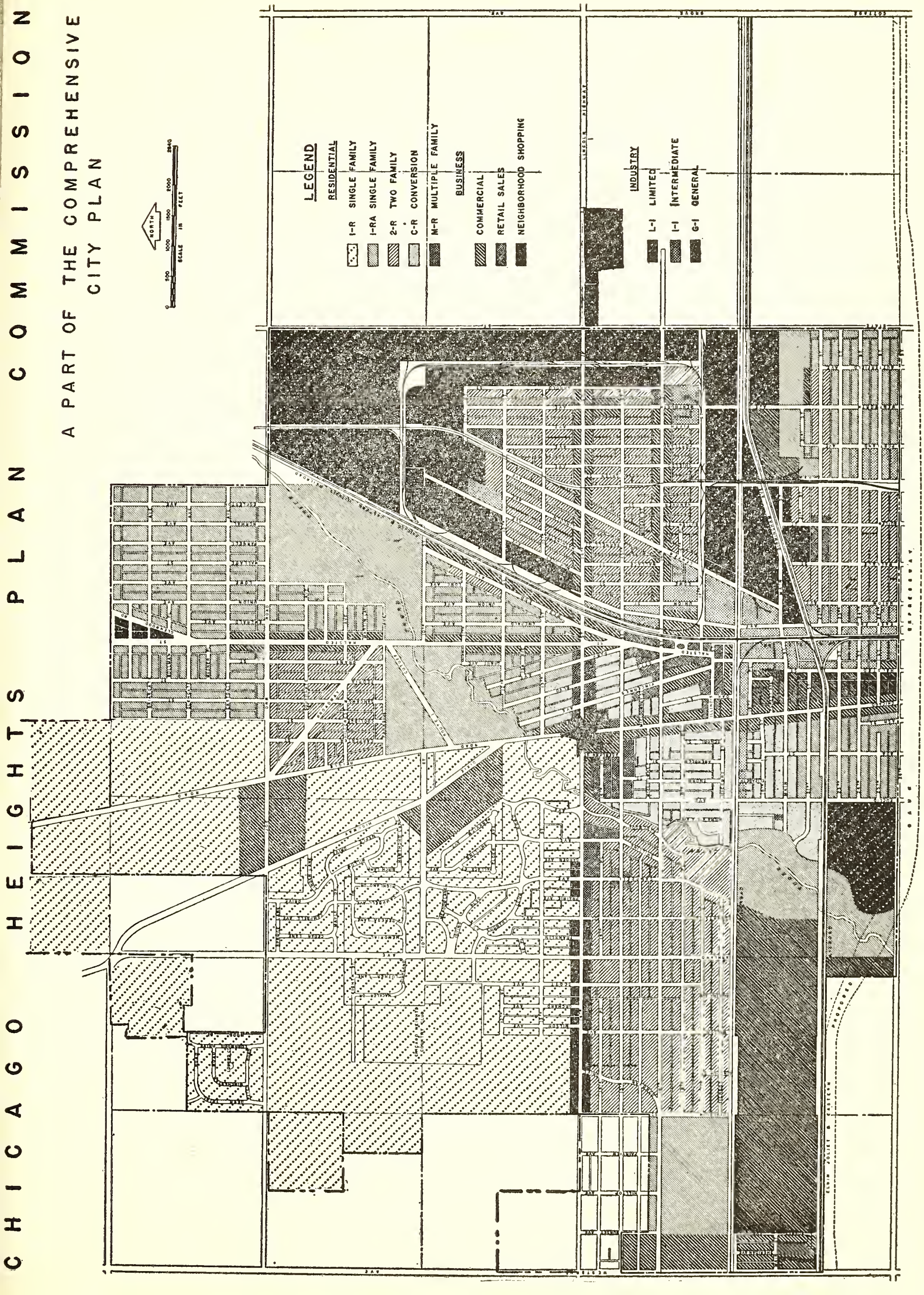
Fig. 5. This map, issued by the Chicago Heights City Plan Commission, shows areal differentiation of land-use allocated to residence, business, and industry. Note the comparatively large areas zoned for industry, especially for general (heavy) industry. Comparing this map with Fig. 2, the viewer will observe the comparative industrial space relationships within the City Limits and the newly developed areas outside the City Limits.


CHICAGO HEIGHTS PLAN COMMISSION
A PART OF THE COMPREHENSIVE CITY PLAN
NORTH
0 500 1000 1500 2000 2640
SCALE IN FEET
LEGEND
RESIDENTIAL
1-R SINGLE FAMILY
1-RA SINGLE FAMILY
2-R TWO FAMILY
C-R CONVERSION
M-R MULTIPLE FAMILY
BUSINESS
COMMERCIAL
RETAIL SALES
NEIGHBORHOOD SHOPPING
INDUSTRY
L-I LIMITED
I-I INTERMEDIATE
G-I GENERAL
LINCOLN HIGHWAY
HALSTED
PROPOSED

which this district might otherwise have upon the city's residences is largely eliminated.

Almost as much area as has been allocated for heavy industry in the Land-Use Plan has been designated for limited industry. This is of the so-called non-nuisance type. It is concentrated, in the main, between the Michigan Central and the Elgin, Joliet and Eastern Railroads and from Western Avenue to Ashland Avenue, and in the area immediately south and east of the downtown business districts (Fig. 5).

Summary and Conclusions

Chicago Heights, on the west end of the Calumet Region, occupies a topographic position transitional between the Chicago Lake Plain and the Valparaiso Moraine, and a commercial and industrial setting peripheral to Methropolitan Chicago. As such, it is favored physiographically by a somewhat elevated rock foundation and landform site, and likewise as a sub-urban community of the Chicago Industrial Complex derives geographic "fringe benefits" in practically all the elements which enter into its manufacturing structure—ready accessibility to capital, labor, raw materials, transportation facilities, and markets.

While favorability of geographic regional situation and topographic site has been a strong conditioning factor of industrial growth, the realization of such growth, of course, was made possible, here as elsewhere, only by man. Impetus toward industrial development in the case of Chicago Heights was the outgrowth of a series of industrial land-promotion programs combined with favored transportation facilities and switching rates.

What equally distinguishes this small-sized but greatly-developed industrial community is the concerted action of a number of civic organizations—The Committee for Chicago Heights, the Manufacturers Association, the Merchants Association, the City Plan Commission, and others—whose objectives is to realize the full industrial and residential potential of the community.

Every industrial community has its problems, and so also in the case of Chicago Heights. Slum clearance is one of such community problems, which is now being resolved with the aid of federal funds. Adequacy of labor supply is a growing concern of some industrialists and other employers of labor. As Chicago Heights becomes more of a labor market, because of new and expanded industry, the demand for laborers will expectedly be met by local population increases and by a more thorough utilization of an expanding labor tributary area.[1]

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[1] Grateful acknowledgments are due the various literary sources cited and the individuals and agencies which have significantly contributed to this geographic survey. These include: The numerous individual plant managers or other officials who have given so generously of their time in supplying questionnaire data; Mr. Peirce Vandercook, Executive Secretary of The Committee for Chicago Heights, for giving us a general preview of Industrial Chicago Heights; Mr. M. M. Thorsness, Executive Secretary of the Manufacturers Association of Chicago Heights, for filling in many of the details of the industrial setting by answering specific

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questions in person and through correspondence; Mr. Arthur Longini, Chief Economist of the C. & E. I. Railroad, for permitting us to consult his to-be-published manuscript, "Industrial-Economic Blueprint," of the area, and otherwise graciously sharing his knowledge on such factors of the environment in which we were particularly interested; Mr. Donald Stonebraker, City Planner, for supplying map material and bringing us up to date on Chicago Heights' planning program, plats, and procedures.

The authors are also grateful for collection and compilation of geographic data by John Clark, Donald Killmer, James Schumacher, and Marilyn Weitkamp, students in the senior author's class in Geographic Problems; also for cartographic assistance by Karl Roberts, another major in the Department of Geography and Geology.

SOIL SCIENCE (AFFILIATE)[1]

ABSTRACTS

Are We Doing the Job? George D. Scarseth, Director of Research, American Farm Research Association, Lafayette, Indiana.—The solution to the "farm problem" appears to be moving further from realization as the issues move into the realm of politics. This status is developing largely through a mass ignorance of what are the basic facts involved. We scientists are primarily responsible, because of the gigantic task of translating our knowledge into forms where it is realistic, stimulating, inspiring, and practical enough to be effective.

As educators, we scientists tend to be the worst. The farmer deals with "whole problems," that reach across all our scientific disciplines. The farmer's action is wise or foolish according to how well he manages to transpose the known into something he can successfully produce and sell. He deals with uncounted variables and is forced to make his decisions according to what he thinks best.

The scientist abhors to make a choice or to give advice unless he is on the safe ground of verified experimental facts. The confirmed knowledge that scientists have, as well as the sound theoretical speculation they can make, based on established principles and laws are better than the blind guesses people are often forced to use. However, to translate facts and natural laws into use so often encounters such barriers of tradition and misunderstanding that only a very few scientists have dared, in all history, to venture into his unhallowed zone.

Some cases will be used to show the failure of following the hard facts of our sciences in our educational efforts and the resulting consequences.

Temperature Effects on the Utilization of Starter Fertilizer by Corn. A. J. Ohlrogge, W. G. Duncan and J. M. Shiveley, Purdue University. —Corn was grown through the seedling stage in the controlled climate facility of Purdue University. Six starter fertilizer treatments were used at three temperatures (60°, 70°, and 80°) with a 16 hour day. Radiophosphorus was supplied in the mono-calcium phosphate fertilizer.

Growth rate was affected earliest in plant development by fertilization at the lowest temperatures. Fertilization was approximately equivalent to 10 degrees of temperature as measured by growth. Phosphate recovery rates increased approximately 50 percent for the temperature increasement of 10 degrees when nitrogen and phosphate were applied in a single band.

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[1] All of the following papers were presented in a separate meeting but are joined with the papers of the Geology and Geography Division.

Some Field Observations of Effects of Deficiency and Luxury Feeding of Corn Hybrids. G. N. HOFFER, Lafayette, Indiana.—The effects of essential nutrient deficiencies and imbalances in hybrid corn plants are illustrated. Many observations of different hybrids during the current year will be discussed with some of the interpretation of the symptoms based on recent work with nutrient isotopes.

Atmospheric Radioactivity from Indiana Soils. W. G. DUNCAN, Purdue University.—Observations made over several months indicate that the atmosphere contains highly variable amounts of radioactive materials. The amount of radioactivity appears to vary with weather conditions but the relationship is complex. The intensity of the radioactivity is greatest at the surface of the soil and decreases with elevation.

It is believed to be an entirely natural phenomenon caused by the presence of small amounts of uranium widely distributed in the soil. Probably the radon gas evolved in the decay of uranium becomes a part of the soil atmosphere and as such diffuses into the air in measurable amounts.

Use of Weather Records on Punch Cards in Solving Local Climatic Problems. L. A. SCHAAL and J. E. NEWMAN, State Climatologist, U.S.W.B. and Purdue University.—Beginning in October, 1955, the Department of Agronomy, Agricultural Experiment Station, Purdue University, entered into a cooperative agreement with the United States Weather Bureau, whereby the two above mentioned institutions agreed to certain responsibilities in assembling valuable past Indiana climatic data on punch cards. After one year of this cooperative effort, some 25 climatic stations with records of 50 years or more in length, have been assembled. These 25 stations are scattered rather uniformly over the state.

Brief explanation of what climatic data have been placed on punch cards and the geographical location of each record which has been punched is given. Specific examples of how similar cooperative projects in other states have applied such data to problems of a climatic nature is illustrated. A discussion of contemplated summaries for rainfall and temperature data at the 25 Indiana stations is presented.

A Survey of the Mineralogy of Indiana Soils[1, 2]

J. L. WHITE, G. TALVENHEIMO,[3] M. G. KLAGES[4] and M. M. PHILLIPPE,[5]
Purdue University

Introduction

Twelve soil types which represent 33 percent of the total cultivated area of the State of Indiana were selected for mineralogical studies in connection with the development of quantitative x-ray diffraction procedures for the estimation of soil minerals (5, 7). These soil types were selected in order that the maximum variations of parent material, physiography, drainage phase and age group were represented. The salient features of the soil types investigated are presented in Table I.

TABLE I

General Description of Soils Used in This Study

No.	Soil Type	Parent Material	Physiography	Major Profile	Age Group
1	Miami sil	Till-mixed	Upland	IV	2
2	Nappanee sil	Till-shale	Upland	II	2
3	Newton lfs	Outwash	Terrace	VIII	2
4	Fincastle sil	Till-mixed	Upland	II	3
5a	Crosby sil	Till-mixed	Upland	II	2
6	Cincinnati sil	Till-mixed	Upland	IV	4
7	Chalmers cl	Till-mixed	Upland	VIII	2
8	Clermont sil	Till-limy-shale	Upland	I	4
9	Frederick sil	Residual-cherty-limestone	Upland	IV	4
10	Zanesville sil	Residual-siltstone	Upland	IV	4
11	Fairmount sicl	Residual-shale-limestone	Upland	VI	4
12	Genesee sil	Alluvium	Bottom land	IV	1

Further information concerning the samples has been given by Breland (1).

Experimental

The surface horizons (A_p) of the twelve soils were separated into silt ($20\text{-}2\mu$) and coarse clay ($2\text{-}0.2\mu$) and fine clay ($<0.2\mu$) fractions.

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[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1042.

[2] Grateful acknowledgment is made to the American Potash Institute, the Purdue Research Foundation, and the National Science Foundation for generous support of this work.

[3] Present address: Houdry Process Corporation, Marcus Hook, Pennsylvania.

[4] Present address: Department of Agronomy and Soils, Montana State College, Bozeman, Montana.

[5] Present address: Agronomy Department, Clemson Agricultural College, Clemson, South Carolina.

The quartz and feldspar contents of the silt fractions were estimated by the x-ray diffraction procedure of Phillippe and White (5) and are shown in Table II. The mineralogical composition of the coarse clay fractions (Table III) was estimated by a combination of the x-ray

TABLE II

Mineralogical Composition of the Silt Fractions (20-2 μ) of the A_p Horizons of Twelve Indiana Soils

No.	Soil Type	Mineralogical Composition, per cent		
		Quartz	Albite	Microline
1	Miami sil	66	9	14
2	Nappanee sil	63	9	15
3	Newton lfs	47	10	13
4	Fincastle sil	65	9	14
5a	Crosby sil	67	9	14
6	Cincinnati sil	67	8	16
7	Chalmers cl	61	11	14
8	Clermont sil	81	7	9
9	Frederick sil	64	11	13
10	Zanesville sil	74	9	12
11	Fairmount sicl	73	8	14
12	Genesee sil	56	10	14

TABLE III

Mineralogical Composition of the Coarse Clay (2-0.2 μ) Fractions of the A_p Horizons of Twelve Indiana Soils

No.	Soil Type	Quartz, per cent	Clay Mineral Composition Parts in ten of each constituent allowing ten per cent for material not registering			
			Montmorillonite	Illite	Vermiculite/ Chlorite	Kaolinite
1	Miami sil	14	0.8	3.1	3.5 (V/C)	1.6
2.	Nappanee sil	14	0.6	4.9	2.3 (V)	1.2
3	Newton lfs	8	. . .	1.7	6.0 (C)	1.3
4	Fincastle sil	12	0.9	4.1	3.0 (V/C)	1.0
5a	Crosby sil	19	0.6	4.3	2.4 (V)	1.6
6	Cincinnati sil	13	0.9	4.4	1.9 (V)	1.8
7	Chalmers cl	10	1.0	4.9	1.6 (V)	1.4
8	Clermont sil	12	0.6	4.4	2.0 (V)	1.9
9	Frederick sil	10	0.8	3.6	3.3 (C)	1.3
10	Zanesville sil	12	. . .	4.3	3.8 (V/C)	0.9
11	Fairmount sicl	10	0.8	5.0	2.3 (V)	0.8
12	Genesee sil	7	1.5	4.7	2.2 (V)	0.6

diffraction procedures of Talvenheimo and White (7) and Johns, Grim, and Bradley (3).

The height of a particular diffraction peak above the background line (for example, BL in Fig. 1) was considered to be proportional to the amount of mineral present.

Results and Discussion

Mineralogical Composition. It is recognized that caution must be exercised in drawing conclusions on the basis of data from surface samples alone. The probable influence of loess on surface horizons in both the glaciated and unglaciated areas of the state and uncertainty of soil-parent material relationship seriously limit attempts to correlate mineralogical composition and the factors of soil formation presumed to be operative.

Some general trends are indicated in the data for the silt fractions. The older soils (Age Groups 3 and 4, Table I) tend to have a higher quartz content and a lower albite content. The relatively high content of sodium feldspar (albite) in the Frederick soil, presumed to be a very old residual soil, would indicate loess influence.

The data for the coarse clay fraction indicate that the residual soils, Nos. 9, 10, and 11, tend to be low in kaolinite. The montmorillonite content is highest in the Genesee and Chalmers soils. The 10 A. mica component in the clay fractions will be designated as "illite" even though the mica may be more closely related to muscovite. Grouped by illite (mica) content the soils rank as follows: high illite—Fairmount, Nappanee, Chalmers, and Genesee; intermediate illite—Fincastle, Crosby, Cincinnati, Clermont, and Zanesville; low illite—Miami, Newton, and Frederick. This grouping is in good agreement with the potassium-supplying power of these clays as given by Rouse and Bertramson (6). A mineral with an 001 reflection at 14 A. appears to be the second most abundant constituent in the coarse clays. It was surmised that the 14 A. mineral was a weathering product of illite.

The fine clay fractions ($<0.2\mu$) contain larger amounts of montmorillonite and illite than the coarse fractions. Kaolinite and quartz are present in small amounts, if at all.

Mica Weathering Sequence. Since the two most abundant constituents of the coarse clays are illite and a 14 A. mineral presumed to result from the weathering of the illite, it was considered worthwhile to examine the mica weathering sequence in more detail. Detailed examinations were made of soil profiles developed on Wisconsin glacial material (4). These soils included a Crosby silt loam [5b], a Miami silt loam, and a Chalmers silty clay loam. The findings for these soils were quite similar; the results for the Crosby [5b] will serve to illustrate principles involved in the weathering of mica in these and similar soils. The location of the Crosby [5b] profile was: Hancock County, NW¼ of NE¼ of Section 20, Township 16 N, Range 7 E. The horizons sampled, depth of sampling and pH were as follows: A_2 4-11″ (pH 5.4), B_2 16-24″ (pH 5.6), C 28″ (pH 8.3).

Portions of the x-ray diffractometer tracings of the silt fractions are shown in Figure 1. Considerable amounts of dolomite and calcite

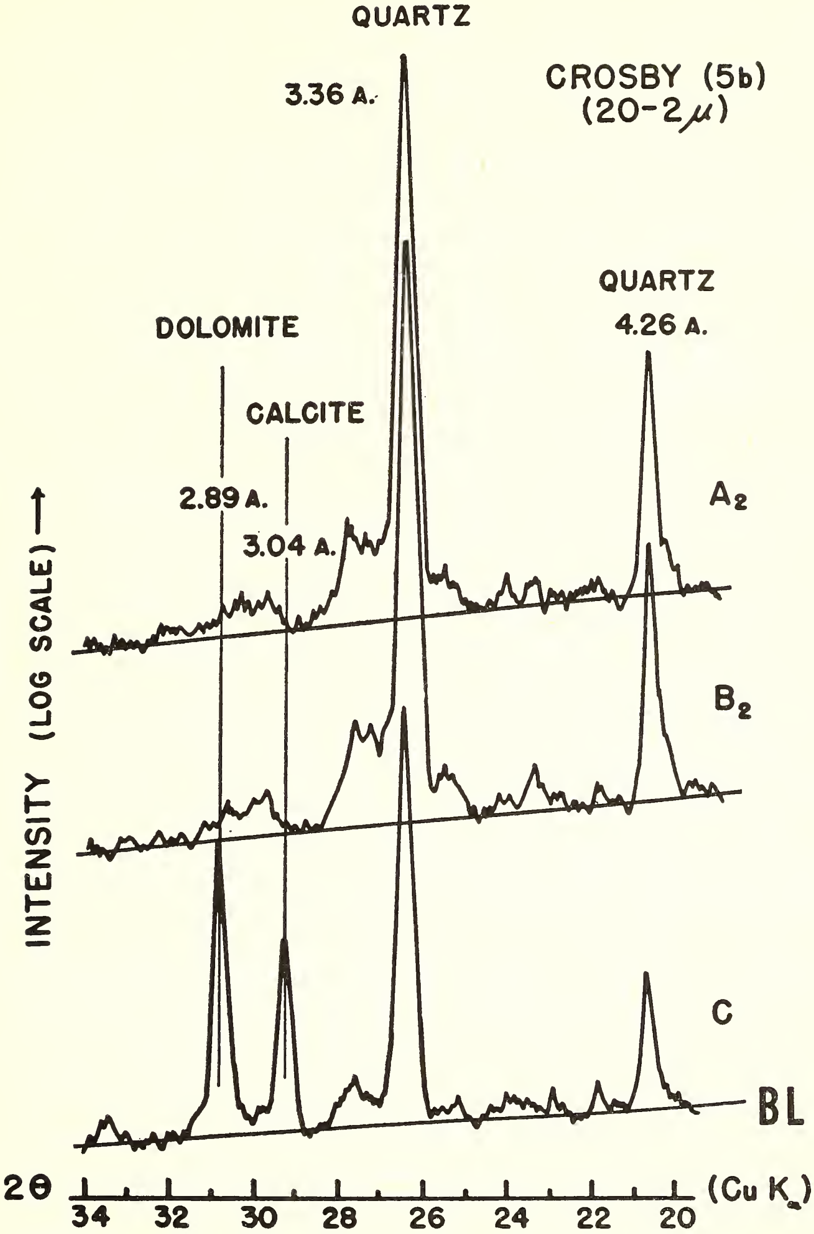

Fig. 1. X-ray diffractometer tracings of the silt fractions (20-2 μ) of the A_2, B_2, and C horizons of the Crosby [5b] soil. The background line is indicated by BL.

are present in the C horizon, but no detectable amounts in either the A_2 or B_2 horizon. The quartz content is about the same in the A_2 and B_2 but somewhat less in the C. Enrichment of quartz in the upper horizons has probably resulted from the weathering of the dolomite and calcite originally present.

Electron micrographs of the 2-1 μ fractions of the A_2, B_2, and C fractions revealed the morphological characteristics of the clay particles in all fractions to be similar. X-ray diffractometer tracings (Fig. 2) of coarse clay (2-0.5 μ) from the A_2 and C horizons show that the quartz and kaolinite content of the two horizons are practically the same. The only apparent difference in the patterns is the decrease in the 10 A. mica (illite) peak in the A_2 horizon with a consequent increase in the amount of 14 A. mineral. It is concluded that the A_2 and B_2 horizons are genetically related to the C horizon in this Crosby soil and that weathering conditions have been relatively mild.

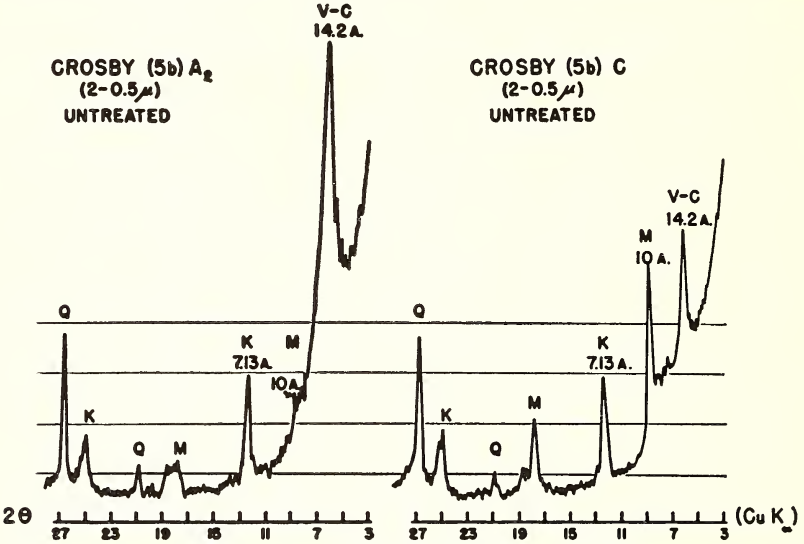

Fig. 2. X-ray diffractometer tracings of the coarse clay fractions (2-0.5μ) of the A_2 and C horizons of the Crosby [5b] soil. The legend for the identification of the diffraction peaks is as follows: Q—quartz; K—kaolinite; M—mica (illite); V-C—vermiculite and/or chlorite.

Since the illite in the fresh Wisconsin glacial till is a dioctahedral mica (4), the material which expands to 14 A. is equivalent to the dioctahedral analogue of vermiculite described by Brown (2). Vermiculite should collapse from 14 A. to 10 A. on heating to 300° C. Heating tests (Fig. 3a, b, c) on the 2-0.5 μ fraction of the Crosby [5b] horizons showed that the 14 A. mineral collapsed rather completely to 10 A. in the B_2 and C horizons, but there was little increase in the intensity of the 10 A. spacing in the A_2 horizon on heating. This indicates the

Figure 3a

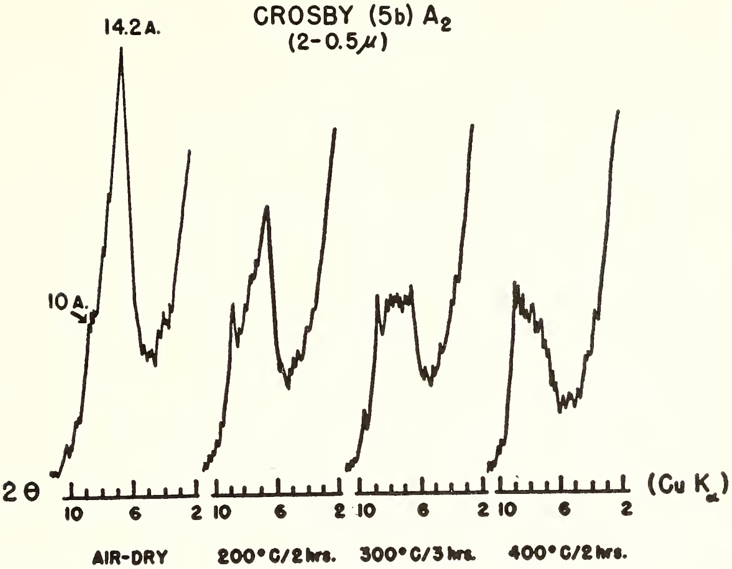
CROSBY (5b) A_2
(2-0.5μ)

Figure 3b

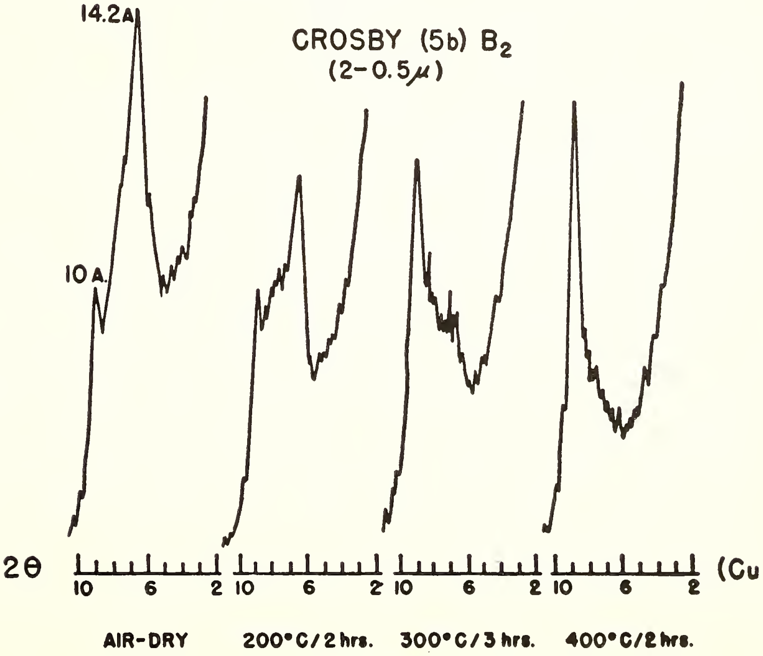
CROSBY (5b) B_2
(2-0.5μ)

Figure 3c

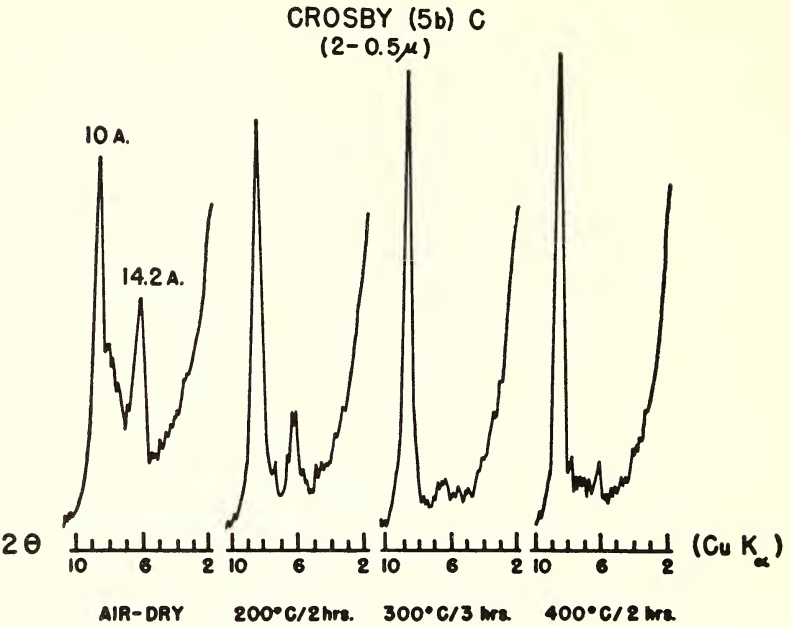

Fig. 3a, b, c. The effect of heat treatment on the collapse of the 14 A. mineral in the Crosby [5b] coarse clay fractions.

presence in the A_2 horizon of inter-layer material which prevents complete collapse of the plates. Klages (4) postulated the presence of positively-charged partially-hydrated aluminum hydroxide between the weathered mica layers in this material. As the amount of the complex aluminum cation increases the properties of the mineral would shift from that of a vermiculite toward a chlorite. Acid weathering conditions would give rise to such complex aluminum cations, and with increasing soil acidity there should be an increase in the amount of the complex aluminum cation occupying exchange positions in the weathered mica. This would result in an increase in the resistance of the 14 A. mineral to collapse on heating. The coarse clay fractions of three soils derived from Wisconsin till, and having pH values from 8.3 to 5.0 were chosen to indicate the effect of soil pH on the thermal stability of the 14 A. mineral. The soils and pH values are as follows: Crosby [5b] C pH 8.3; Miami [1] A_p pH 6.2; Newton [3] A_p pH 5.0. From Figure 4 it is evident that with increasing acidity there is a decrease in the proportion of the 14 A. mineral which can be made to collapse completely to 10 A.

Soils micas which behave similar to the Crosby [5b] C have been designated in Table 3 as vermiculite (V); those behaving similar to

Miami [1] A_p have been designated as intermediate between vermiculite and chlorite (V/C); those reacting in a manner like the Newton [3] A_p have arbitrarily been called chlorite (C). It is recognized that the Newton clay is not a true chlorite, but its thermal stability indicates it is an intergrade between vermiculite and chlorite and it is here considered as being more closely related to chlorite.

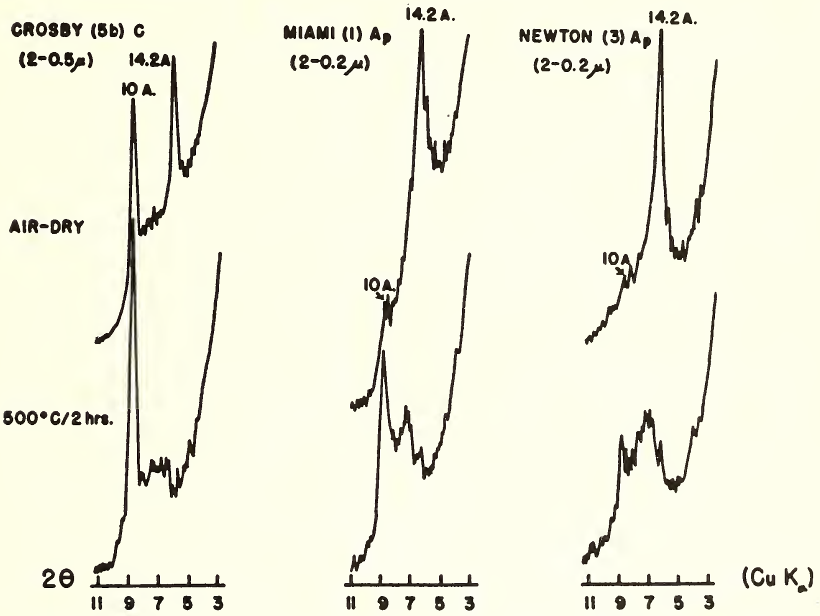

Fig. 4. The effect of soil pH on the thermal stability of the 14 A. mineral in the coarse clay fractions of the Crosby [5b] C (pH 8.3), Miami [1] A_p (pH 6.2), and the Newton [3] A_p (pH 5.0) horizons.

Some of the properties of weathered micas are of considerable agronomic significance. For example, a high layer charge on the clay may result in potassium entrapment or "fixation." This is illustrated for the Fairmount clay in Figure 5 by the effect of potassium-saturation and air drying in collapsing a considerable proportion of the 14 A. mineral to 10 A. The availability of potassium to plants is reduced by such a reaction. Under acid weathering conditions the aluminum hydroxide cation complexes may occupy exchange positions and reduce the tendency for potassium fixation to occur. The presence of aluminum hydroxide cation complexes in weathered micas may also be an important factor in controlling the activity of aluminum ions in the soil solution. This becomes significant in its effect upon the phosphate equilibrium in the soil.

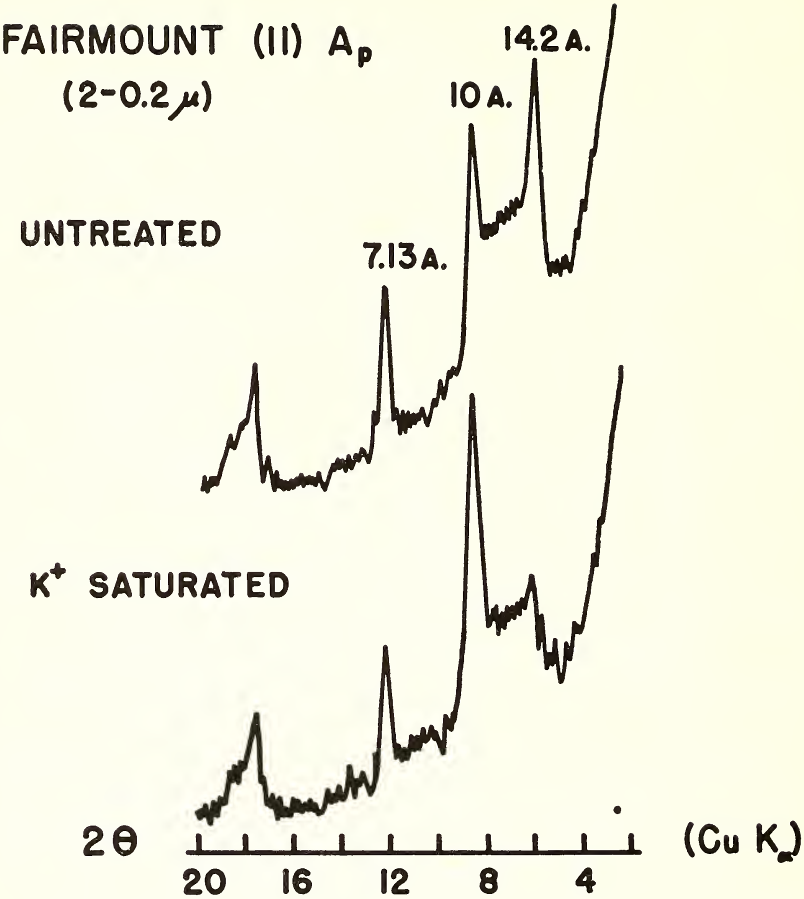

Fig. 5. The effect of potassium-saturation on the collapse of the 14 A. mineral in the Fairmount [11] A_p coarse clay fraction.

Summary

Mineralogical studies of twelve soil types which represent 33 percent of the total cultivated area of the State of Indiana indicate that the predominant constituents of the clay fractions of these soils are quartz, kaolinite, mica and vermiculite-chlorite assemblages.

Detailed mineralogical studies of the Crosby, Miami, and Chalmers soils reveal that the most prominent weathering trend in the clay fractions of soils derived from glacial till is the mica-vermiculite-chlorite sequent.

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Measurement of the Fineness of Agricultural Limestone[1, 2]

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Agricultural limestone is produced in Indiana by crushing limestone rock. The material used for limestone applications to soil is either all of the stone crushed to a small size or else it is the finer material screened from the limestone used in the road building industry. The limestones presently being used in Indiana vary widely in the proportions of fine and coarse particles present.

A study of the effect of the fineness of limestone on crop yields was made in field experiments at two locations conducted by the Agronomy Department between 1921 and 1945 (1) (3). The results of these experiments together with those conducted by neighboring states indicated that fineness was an important characteristic of agricultural ground limestone. From this field study it was possible to determine the effects of fineness of limestone in increasing crop yields. The amounts of limestone of several ranges in fineness required to give equivalent results are shown in table I. The particle size distribution of limestone was evaluated arbitrarily on the basis of the amount passing a 60-mesh sieve. The objective of the research reported here was to determine if one sieve could be used to characterize limestone fineness and to determine which sieve would give the highest correlation.

TABLE I

The Effect of Fineness of Agricultural Limestone on the Amount to Apply for Equivalent Results

Fineness Percent Passing a 60-Mesh Sieve	Equivalent Amounts of Limestone Tons per Acre
41-100	1.0
31- 40	1.25
21- 30	1.50
10- 20	2.00

Procedure

The limestone samples used were from a group collected monthly by the County A.S.C. Committees from each operating quarry in each county. Ninety-nine samples were selected from this source in the ordere received. The samples were mixed and subdivided with a riffle to obtain the sample to be used for the analysis. They were sieved through

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[1] Purdue University Agricultural Experiment Journal Paper No. 1041.

[2] The author wishes to acknowledge the assistance of Mr. G. A. McKim who ran the sieve analyses and the Statistical Laboratory for performing the statistical analyses.

U. S. standard sieves No. 8, 20, 40, 60, 80, 100 and 200 on a Ro-tap shaking machine with a shaking time of five minutes. The amount passing each sieve was determined as a percentage of the total sample.

Experimental Results

The relative value of the limestone samples was determined according to a method developed by Bear and Allen (2). Using this method, the percentage of each size fraction was multiplied by a factor which is related to the rate at which this size fraction dissolves in the soil. Two limestone values were used; one in which the limestone particles above 60-mesh were evaluated at 1.00 and a second in which the particles smaller than 200-mesh were used as the base. The former measurement would evaluate the limestone 2.3 years after application, the latter 3 months after application to the soil. The figures used to determine these limestone values are shown in table II. The fraction of the limestone in each size range was multiplied by the appropriate factor and the values totaled to give a value for each limestone sample.

TABLE II

The Values Used to Determine the Relative Effectiveness of Limestone Samples Differing in Particle Size Distribution

Particle Size	3 Month Value	2.3 Year Value
4- 8-Mesh	8.1	21.2
8- 20- "	17.8	45.1
20- 40- "	41.0	80.3
40- 60- "	67.0	98.7
60- 80- "	86.5	100
80-100- "	90.5	100
100-200- "	99.0	100
less than 200-Mesh	100.00	100

The percentage of the limestone passing each of the sieves was correlated with the limestone values for the 99 samples. A multiple regression analysis was determined on several combinations of sieves to determine if the combinations gave a higher correlation than any single measurement. The results of these correlations are given in table III.

The coefficients of determination shown in table III express the percentage of the variation in limestone values that is measured by the sieve or sieves used in the correlation. For the 2.3 year evaluation, the 20-mesh sieve gave the highest value measuring 98.2 per cent of the variation. For the 3 month value, a value which characterizes a wider range of particle sizes, the 40-mesh sieve gave the highest value, measuring 98.9 per cent of the variation. The 60-mesh sieve measuring 96.1 per cent of the variation was not significantly lower statistically. None of the multiple correlations where two or more sieves were used gave a significant improvement in the coefficients. This indicates that, for the samples used, there is no advantage in using more than a 40

TABLE III

Coefficients of Determination for the Correlation of Limestone Value with % Passing One or More Sieves

% Passing Sieve No.	Correlated with 2.3 year value	Correlated with 3 month value
Simple Correlations		
8	0.622	0.474
20	0.982	0.928
40	0.928	0.989
60	0.856	0.961
80	0.823	0.942
100	0.791	0.920
200	0.589	0.730
Multiple Correlations		
8 + 100	0.906	0.947
8 + 60 + 100	0.955	0.979
8 + 200		0.824
20 + 100		0.992

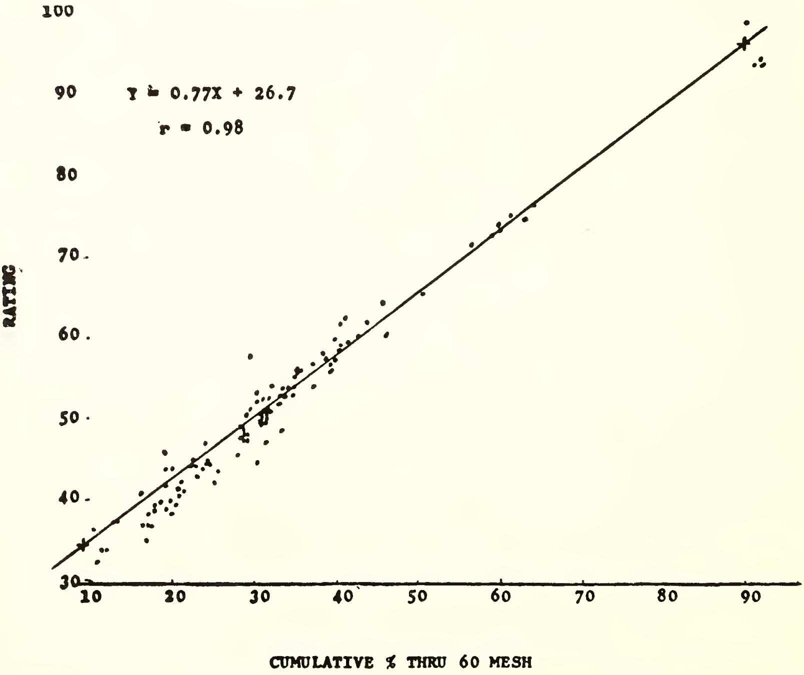

Figure 1. The Relationship between the Value of Limestone and the Percentage which Passes a 60-mesh seive.

or 60-mesh sieve. The relationship between limestone value and the per cent passing a 60-mesh sieve is shown in figure I. The correlation coefficients of all combinations of the sieves is given in table IV. The correlation of the amount passing one sieve, for example the 60-mesh sieve, with the amount passing other sieves indicates how well we can predict what will pass other sieves by using this one sieve. The 40, 60 and 80-mesh sieves have higher correlation coefficients in general with the other sieves than do the 8, 20, 100 and 200-mesh sieves. In all of these data, high correlation coefficients are needed since limestone value figure contains a component of any size fraction which is being correlated with it.

TABLE IV

Correlation Coefficients for the Correlation Between Fractions Passing Various Sieves.

Sieve	8	20	40	60	80	100	200
8		.74	.63	.59	.58	.57	.49
20			.95	.90	.88	.86	.74
40				.99	.98	.96	.85
60					.99	.98	.89
80						.99	.91
100							.94

The use of a sieve which is in the middle of the particle size range such as the 40 or 60-mesh sieve gives a high correlation with the limestone value and is a good indicator of the particle size distribution of agricultural limestone. The use of more than one sieve did not give a significant increase in the correlation coefficient.

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Trials of the Catena-Drainage Profile Keyform as a Frame of Reference in Pedological Taxonomy[1]

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Assuming that "natural classifications" involve (1) recognition, or mental "creation" of units of a discipline and (2) arrangement of those units according to their likenesses and differences, the writer has prepared a "Key" to classifications of Indiana soils by drafting a series of tables and papers (1, 2).

The original "units" were soils already established by soil surveys so the main task was the second step, or the "arrangement" of those units. Even then the operation was chiefly one of crystallizing some common practices of soil surveyors into certain forms.

Reflecting customary thinking of field men, the key assumed the form of a simple tabular arrangement of soil names on lines and in columns with distinguishing descriptive terms at the sides of lines and as headings of columns.

Soils named on the same line were linked by similarities in their descriptions of parent materials, age, vegetation and climate, but differed in features reflecting differences in water regime. Such a grouping was a well recognized class long before the term "catena" was applied to it. Milne had used "catena" (8) somewhat differently, yet approved of this (3) use of his term with the Indiana Key on the basis of his personal acquaintance with Indiana soils and soil survey work.

In the key an attempt was made to array the soils of each catena on their respective lines in such a way that the names of soils with comparable water regime should appear in the same column and conform to the same general description.

In some cases the soils of different catenas, but named in the same vertical columns, are very much alike especially in upper horizons, but, due to the wide range of characteristics found in the complete set of soils, about the only sure generalization is that members of each catena are located on their line according to features reflecting "drainage" and are arranged in gradations with the names of more closely related soils being adjacent and those unlike being farther apart.

However within each column there is a general similarity in essence of the criteria, or the position of each solid relative to other members of its catena.

The general concepts exemplified by the soils listed in each column came to be called "major drainage profiles." The original table had each column headed by a Roman numeral, which, without premeditation but by common usage, became the general name of the general concept—such as "I Profile," "II Profile," etc.

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[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1036.

The original order of the column headings was based on a diagram (2, 3) illustrating gradations in a "hydrologic sequence" which may comprise a catena. In turn, that diagram probably was influenced by the Illinois Soil Survey which used Nos. 11, 12, 13, 14 and 15 for a set of soils grading from very imperfectly drained flats to well drained slopes, and comprising part of a catena—although that term was not in use.

In nature soils may occur about as illustrated in that original diagram, or in a variety of other patterns. Also in tables or diagrams other arrangements may have advantages in some catenas. However, the Roman numerals, with their respective significance as names established by the first usage, are retained with the same meanings in any diagrams or text, just as the words "dogs and cats," refer to the same animals as "cats and dogs"—regardless of word order.

The catena-drainage profile key form was tied to field legends and evolved with several modifications into a device found by experience to be useful, convenient and reasonably adequate for arranging most of the individual soils which were recognized in the soil surveys of the region.

Naturally the principles found good for classifications in pre-key soil surveys could be assumed to be equally good for new work so the Key became a guide for setting up classifications for each new County Soil Survey. New soil separations thus set up would, of course, fit into appropriate pigeon holes or boxes of the key.

Considering all catenas there were 10 steps in the complete range of hydrologic sequence characteristics, hence 10 columns in the key to provide for 10 different major drainage profiles. However, no catena had recognized soils for all 10 profiles so the table had a number of empty boxes. Such empty boxes naturally raise questions whether unknown soils exist and should be recognized to fill the voids. In some cases the "new" separations so predicted from the Key were actually found and named. The recognition of one new soil in a new catena automatically indicated the theoretical possibility of all other members of that catena. However, many catenas had been mapped for a long time without showing any real need for the full number of catenary steps. Fundamentally the Key is a device to arrange existing units and not something to force separations where the nature of soils make them illogical or impractical.

After this Indiana Key had been time-tested and found useful the principles, consciously or unconsciously followed in its construction, were extracted and generalized in paper on "Some Aspects of the Catena Concept" (3).

Later on a study of the soil literature revealed great confusion and varied views about the catena concept and terminology. This was discussed in a paper called the "Catena Cauldron" (5). It would be impossible to conform to the views of all of the authorities, so the Indiana viewpoint was retained.

In 1944 the writer speculated about the feasibility of using the Catena-Drainage Profile Keyform as a frame of reference (4) in constructing a world soil classification. While this device seemed fairly good for the soil conditions where it was developed, the question was whether, how or where it might fail to be suitable for arrangement of soils recognized by pedologists elsewhere.

It was suggested that, if "local" keys of soil separations were made everywhere by arranging the individual units according to the same basic principles as those followed in the Indiana Key then those local tabular keys could be arranged logically in several ways in reference to each other.

It was recognized that the concept of "local" used in this way is about equivalent to considering different climatic complexes which have different soils characteristic of them in comparable sites, etc. The paper mentioned above considered "different" climates in terms of different combinations of rainfall, temperatures and evaporation. That simple, theoretical diagram illustrating the general idea did not take into account the patterns of wet-dry seasons, and did not make use of studies which have recognized certain climates as significant in pedogenesis. Actually a relatively small number of kinds of "climates" may be needed, but the decision on numbers should not rest on some theory about climatic specifications, but upon actual different soil separations which must use different climatic factors to explain the characteristics which differentiate them.

It seemed logical that this general proposal is feasible because all soils are conceived to be functions of "5 canonical factors" (7) and every soil must reflect every factor. Hence every soil must have characteristics which could define its catena, and also features which specify its water regime and therefore its major drainage profile. If so, they can be arranged in tabular keys in accordance with these functions and characteristics.

Of course, as well known, almost all older soil separations and many newer ones are complexes or "polymorphs" (3). That is, they are broadly defined to cover several boxes in a tabular key. They are not true species, but can be placed relative to each other on the key grid.

Since raising questions about the keyform the writer has had some opportunities to observe soils in all states of the union, in Canada, Mexico, Hawaii, Guam, Japan, Thailand, Burma, India, Egypt, Italy, Germany, Austria and other countries. Everywhere the general principles for recognition of catenas and major drainage profile members of them seemed to be applicable, even though variations and complexities abound.

The soils themselves are more conformable to a natural system than are the soils men of different places, because of the infinite capacity of the human mind to vary. Thus, the writer could "see uniformity in soil characteristics and relationships according to his viewpoints, where the local classifications would not coincide so well. That is, the specific criteria and techniques produce different taxonomic and therefore different cartographic units, but the soils themselves could be defined and arranged uniformly.

For instance, in Bavaria some excellent soil studies are made, partly in connection with land valuation, by following a systematic grid for borings, pits, samples, analyses, etc. Apparently fields, rather than natural soil areas, are a first consideration, although the latter will show up in maps. A field may be characterized by its major components, although allowance is made for minor components. The places examined under the grid system may fall at any point on the natural soil pattern and may represent a transitional condition which the American Soil Survey would try to avoid because borings are made in places away from boundaries, and nearer the centers of areas judged to be "typical" of some type. The American system probably produces fewer and more uniform concepts while the German method seems to produce a wider variety of soils, and a set of separations which would not fit a catena-drainage profile key so well because they were not made by such specific judgments. They probably could be placed in such a table but would fall in intermediate positions, or perhaps have some special features not considered as criteria in setting up a key.

It may be an open question whether a systematic approach will hinder full, accurate and reasonable evalution of nature, or produce a better result. In general, classifications try to have consistent standards and set up codes for uniformity. In pedology there is much opportunity for divergence, and independent studies may give a confusion of tongues like the tower of Babel. There may be more difference between two schools of thought in the same language than between views of people with different languages.

In a Soil Survey of Hokkaido, Japan (1946) the writer used a field legend and made separations in harmony with the Catena Drainage profile viewpoint, as previously described (6).

In Burma the writer undertook a "land classification" of extensive areas by photo interpretation with a group of trainees. Assuming that natural principles are valid everywhere the classification was set up with coded 6-digit symbols which indicated climate, vegetation, catena (from geology-material and age) drainage profile, topography and erosion. In spite of differences in latitude, longitude, climate, geology and agriculture the same sort of symbols and judgment were used successfully in Burma as in Indiana.

Although opportunities for field checks of office interpretations were limited, there were gratifying confirmations in most inspections of the classification.

For example, areas marked 8 (for VII, VIII, and IX profiles) were found to be wet basins with dark, mottled soils. An exception was where both aerial and ground observation showed a wet swale, but the surface soil was reddish for some undetermined reason.

Another example was where pictures showed karst land-forms typical of limestone materials with varied slope classes. As expected, a typical black Rendzina profile occurred on the steeper (D) slopes, while shallower red soil was found on C slopes with deeper red soil on the B slope. Some depressions with high water tables showed the normal water-logged profiles of VIII profiles.

In the important agricultural areas of the Irrawaddy valley some rather sharp distinctions could be drawn from the picture patterns which were confirmed by field checking. There were differences in materials, drainage profiles, degrees of weathering with age, etc. It was even possible to see where brackish tide waters affected the delta lands, in contrast with the older areas leached by heavy rains, or fresh alluvium deposited by fresh waters along the river distributaries.

In the more lateritic regions of Burma the deeply weathered profiles exhibited a variety of high iron layers with somewhat the expected color shifts with drainage, but the porous structure did not allow the degree of imperfect internal drainage which occurs on flats or gentle slopes in Indiana soils.

In Italy, near Rome and in the Po Valley many soils had familiar appearances as would be expected from the site factors, much like in Midwest soils. They should fit in catenas.

In the glaciofluvial and loess lands of the Danube river and its tributaries the soils resemble many corresponding types in Indiana, with some modifications and odd occurrences. For instance on gravel plains near Munich there are some areas (not basins) of muck and/or marl on the surface which are due apparently to rise of ground waters which carry the runoff from the Alps.

Also some soils comparable to the Fox types in Indiana seem to have less advanced horizon development, perhaps due to less age or different materials.

Loess deposits in Austria are extensive and some soils are comparable to those of Indiana but apparently the climatic balance is not favorable to the leaching which produces much soil acidity, or pronounced textural profiles.

All in all, the writer has increased faith that the tabular, Catena-Drainage Profile Key is a device which gives very sound arrangements of soil units in "local" regions, and the soils of all regions, if so keyed locally, can be clearly interrelated by arranging the local keys in logical order.

All of the intricate and significant facts and principles revealed by applied and fundamental researches with physical, chemical and biological tools depend for their importances, upon connecting them with soil taxonomic units, morphological nature and geographic distribution of kinds of soils. Without such tie-in these scientific data are just information about dirt in a sample, on test-plots in a field. A soil key should help use of such data, with or without soil surveys.

Soils are three dimensional bodies whose chief characteristics for recognition, description, interpretation and utilization are in surface features from which unseen profiles are inferred. The important profile features must be connected with surface forms and geography. The whole soil complex needs be located in a three dimensional framework of climate, catenas and drainage, with details of slope and erosion being important local features and present cover or land use being of great practical importance.

These items can be indicated on tabular keys and a consideration of soils can be started from any of various key facets which may be known and proceed from there to other facts which identify soil types and their significance.

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HISTORY OF SCIENCE

Chairman: WILLIAM J. TINKLE, Anderson College

DANIEL DENUYL, Purdue University, was elected chairman for 1957

ABSTRACTS

History of Farm Planning in Relation to Soil Conservation in Indiana. S. E. BOWMAN, U. S. Soil Conservation Service, Bloomington.—No doubt there has been some degree of soil conservation practiced since the first settlers tilled the soil of Indiana.

Land had been abandoned due to erosion before the turn of the century. Purdue University experimented with terracing in the early 20's.

Little farm planning for soil conservation was done in the state prior to 1933 when the Soil Erosion Service was established. In 1935 this became the Soil Conservation Service.

In the early CCC camp days the impetus was mainly on gully erosion. Gradually, proven control practices to combat sheet erosion were introduced from older farming areas.

As a guide to farm planning for soil conservation the need for soil inventories became apparent. From a rather sketchy beginning this has developed into comprehensive land capability maps.

Farm planning since 1933 has developed from a single practice demonstration to a complete soil and water conservation program for the farm. There may well be a number of equally good conservation plans for a given farm.

Generally speaking, state wide, there has been some trend away from mechanical practices to a more intense use of vegetative practices for conservation.

Farm planners with the SCS now have the responsibility of layout and certification of mechanical practices with the ASC program.

History of the Richmond Scientific Association. LAWRENCE J. KING, Boyce Thompson Inst. for Plant Research.—A "History of the Richmond Scientific Association (1873-1878)" presents the cultural background of this Indiana community from the beginning, and the factors of that era which led certain of its leading citizens to the founding of this association. The role of staff members of Earlham College and of other Quaker schools, the local medical men together with prominent citizens is developed. In this post-civil war period with the echoes of the Darwinian controversy still strong in the ears of the public, the increasing activity of state surveys for the development of natural resources, the interest in geology and evolution, and particularly the study of fossils so well represented in the Whitewater Gorge strata, as well as the thirst for things new always so closely associated with the pioneer spirit—were all factors in the development of this group.

This, the era of the Greek literary societies, the various private schools and Female Academies, the Athenaeums, the private natural history collections or "cabinets," the magic lantern and the itinerant speakers and travelers all indicated the desire to be informed. With the leisure time afforded these good citizens they turned their efforts to cultural advancement.

In later years with the declining interest of medical men in natural history matters, more widespread public school education, improved newspaper, magazine and farm papers, and specialized societies in the local schools and colleges the need for organizations such as this one considerably diminished. Following the organization of the Indiana Academy of Science in 1885, with three Richmond residents as charter members, the outlet for more highly technical reports and for professional contacts was then established.

Aspects of Conservation of Man in Indiana

STEPHEN S. VISHER, Indiana University

Although most people consider that conservation deals with wildlife, forests, fish, soil, water and minerals, the most significant aspect of conservation is that of man himself. How can mankind be helped to contribute more effectively?

In Indiana, five major methods of increasing the efficiency of people are 1) by better education; 2) by curtailing premature deaths; 3) by increasing vigor as well as prolonging life; 4) by making available better tools with which to work; and 5) by improving incentives, goals or objectives.

In the early decades of Indiana's history very few people had more than a little formal education; now most young adults are high school graduates, many have had college training; and a much larger percentage of our young adults have had post-graduate studies than had even 18 months of total schooling a century ago. The education has become increasingly diversified or enriched, permitting people of varied interests to receive help in the subjects of their special interest. For example, while at Indiana University a century ago, there were only a very few course offerings, now there are many hundreds of courses and scores of diverse curricula.

Formerly, a large share of all infants died, and many other children died before reaching adulthood. The death rate of adults also was high. The vast improvement in the prospects of attaining a "ripe old age" is the result of numerous earnest efforts, in many lines, including improved sanitation, diet, treatment of contagious disease, and surgery. Indiana has contributed notably in this work. One example is Harvey W. Wiley, the person chiefly accredited for the federal pure food and drug act passed in 1906. A postage stamp bearing his portrait was issued in 1956 to honor him. Other Hoosiers who contributed notably in the medical field were J. S. Billings, the famous bacteriologist and medical educator and historian who was awarded honorary doctorates by Edinburgh, Harvard, Yale, Hopkins and Oxford; G. F. Dick, the discoverer of inocculation for scarlet fever; Frank C. Mann, long director of research at the famous Mayo Clinic. John N. Hurty and Thurman B. Rice contributed much to the health of people in Indiana and elsewhere. Three Indiana pharmaceutical concerns also merit mention here: Eli Lilly & Company, Meade Johnson Company of Evansville, and Miles Laboratories of Elkhart.

Increasing the vigor or activity of people is scarcely less important than prolonging life. This has been accomplished partly by improving health with better diet, more wholesome living and working conditions, and increased incentives.

The increased efficiency of people attributable to improvement of the tools with which they work is widely illustrated. For example, farmers now can produce at least ten times as much as equally-able and hard-working farmers could produce a half century ago. In manufacturing the contrast is even greater. With the help of equipment worth on the average several thousand dollars, a factory worker can produce many times as much goods as could a person a century or even half a century ago. Likewise, with the help of labor-saving devices and mass-produced products, a housewife can prepare the meals, clothing, etc., for a family in only a small fraction of the time that was formerly required. The improvement in the transportation of goods and ideas made possible by better tools is spectacular.

The improving of the incentives of the people is especially significant in increasing their efficiency. This requires special education, only a part of which can be supplied by schools. Almost essential are wise leadership and worthy examples; good laws are also important.

Improving the inherent ability of the people is a method of notably increasing their productivity, but we have not been successful in this respect in Indiana. Indeed there is considerable evidence that the average person now is less able than the average was a century ago. The fact is that many of our people are the children of parents who possess less than average ability and vigor, while many of our better endowed people have an insufficient number of children to perpetuate themselves.

Hence, although in many respects Indiana has made excellent progress in increasing the efficiency of our people, much remains to be done in each major line, and especially in the last mentioned, improving the inherent quality of the population.

Conservation of Germplasm of Domestic Species

William J. Tinkle, Anderson College

The attempted improvement of animals and plants through breeding is largely a process of conserving the best genes. By selecting superior individuals to become the parents of the next generation the relative number of desirable genes in the group may be increased. No geneticist claims that the genes themselves are improved but the relative numbers of useful and harmful genes are so recombined that the animals and plants serve man's needs better. Rarely a new gene appears through mutation, and if the character which it engenders is useful to man it may be maintained by breeders, thus incorporating something new.

It is out of place, however, to think of a new breed or variety as a new entity, unrelated to its parent generations, as Harwood seems to have done when he entitled his book on Luther Burbank, "New Creations in Plant Life." A mutant character is indeed new, but it is only one among many characters which compose the plant or animal. Furthermore, most new varieties do not include a mutant but are new assemblages of old characters.

Wild Ancestors

Nature has provided many strains of useful plants and animals which man has simply appropriated and propagated. An example in Indiana is the wild turkey, of which the domestic bronze breed is a lineal descendant, unchanged to any great extent. Examples of appropriated fruits are wild plum, paw paw, persimmon, and the brambles. Many desirable strains of organism have been imported from distant lands and either propagated in the pure form, or crossed with other strains in order to combine desirable characters from two strains into one. An example is the Regal lily, which was secured by a mule caravan sent for that purpose into western China. The Chinese hog *Sus indica* (1), having short head and legs, prolific and easy to fatten, was imported into southern Europe in ancient times, whence it was brought to America to become the principal ancestor of our lard type hog.

Thus, while it would gratify our self esteem to think that breeders have built up all of our varieties and breeds from incipient wild strains, the facts teach us that the wild strains often were superior. A further example is the wild ox of Europe, *Bos primigenius* (2) or urus. Unfortunately it is confused in the literature with the European bison, *Bos bonasus,* which differed very little from the American bison, and was distinct from the urus. This wild cow was described by Pliny, Tacitus, and Baron Herberstein, as being six feet tall, black to gray, light around the muzzle and down the back, having no long hair as in the bison. A horn from one large urus held twelve quarts. Although the wild form became extinct in the 17th century, this type was the ancestor of the Holstein and Galloway breeds and possibly of all the European cattle.

Likewise the Arabian horse seems to have been an outstanding type even before man tried to improve it. Ridgeway (3) thinks the Arabs did not develop the breed, since they do not know the principles of breeding but consider the mother to be all-important. He says they secured them from the Egyptians, who had gotten them from the Libyans, and the Libyans in turn had found them as an indigenous breed of North Africa. To this agrees an account of Herodotus about the Egyptians trying to drive out the invaders known as the Shepherd Kings. They could not drive them out until they had secured horses from the Libyans.

Early Neglect

The first white settlers in Indiana brought with them live stock which had descended partly from these superior strains. But because of poor feeding and housing and absence of selection, both in Europe and America, they had deteriorated. Bidwell and Falconer (4) say that often the likeliest heifers were sold to the butcher. A contributor to the magazine called the "Cultivator," 1838, describes the native cows as follows: "They are a mixture of every breed . . . such perhaps as they were before science and attention had improved them. . . . This mixed breed are not very celebrated for anything; some of them are good milkers as far as quantity is concerned, but as for quality of the milk and aptitude to fatten they generally fail. . . . They are small, short bodied, thin and coarse haired, steep rumped, slab sided, having little aptitude to fatten or to lay the fat on the right place. . . .

"The weight of cows when slaughtered averaged 450 pounds; steers weighed 600 pounds, and oxen 875 pounds."

A similar report is given by N. S. B. Gras (5) as follows: "Observers agree that the live-stock in America up to 1790 was treated with inhuman neglect, partly an inheritance from Europe and partly a necessity of the times and circumstances. Even as late as the 1870's it was necessary for the Grange to encourage careful treatment of live-stock. But little special fodder was grown for animals and shelter was either inadequate or non-existent."

The hogs brought by the early settlers were descendants, not of the Chinese hog, but of the wild boar of northern Europe, *Sus scrofa*. These long-nosed, sharp-backed, late maturing swine roamed the woods, subsisting on grass and acorns, and were contemptuously called "razor backs" and "elm peelers."

Effort to Improve

Improvement of these lamentable conditions came about partly by the improvement of prosperity. When barns and fences were built and enough land was cleared not only for grain but also for hay, live stock received better care.

But the improvement of the animals themselves, the securing of individuals with better germplasm, came largely by importing improved breeds from Europe.

Modern breeding methods began with Robert Bakewell in England about 1760. At that time, English cattle were very heterozygous, due to the practice of mating native cows with bulls imported from other countries. Having traveled widely over England, Bakewell chose the best cattle he had found; a bull from Mr. Westmoreland and two heifers from Mr. Webster, and used these three individuals as the sole parents of his herd. Mating their offspring among themselves and keeping only the best, he soon had cattle which attracted much attention.

The Collings Brothers and Thomas Bates, who were breeding short-horned cattle, heard of Bakewell's success and followed his methods. They kept records of their individual cattle in herd books, and after some years these books were closed; that is, after this time no animal could be recorded as a member of the breed unless both of its parents had been so recorded. The first Shorthorn herd book (6) in the United States was compiled by Lewis F. Allen of Black Rock, N. Y., and published in 1846. In 1882 it was purchased by the herd association for $25,000.

This close breeding, the mating of near relatives, was necessary in order to predict what characters the calves would have; to insure that they would closely resemble their parents. But close breeding must be accompanied by selection because some inferior calves are produced thus and they must be discarded. But the better the germplasm of the parents, the fewer will be the defective offspring.

In 1825, Edward Talbott (7) brought from Kentucky to Jefferson County, Ind., two young cows and a bull, of Colonel Sanders' 1817 importation of Shorthorn cattle. It is hard to say whether this was the first such importation into the state but it was among the first.

Beginning about 1832, the county fairs exhibited live stock of the improved European breeds, and these, having been bought by farmers, were crossed with native cattle and resulted in a great improvement in size, early maturity, and quality of beef. The invention of the cheese factory in 1851 led to interest in improving dairy cattle.

The breeds of sheep and goats were mostly developed in Europe, like the cattle. The hog breeds, however, were mostly built up in this country, largely from imported stocks, both *Sus scrofa* and *Sus indica.*

Early Corn Breeding

The early settlers of our state seem to have given better care to plants than to animals. Corn, *Zea mays*, the principal crop, had been developed by the Indians into all the types which we have today, namely flint, dent, flour, and sweet, and they gave careful attention to the selection and drying of seed. Thus the white settlers had a good example set before them and most of them followed it.

The American Indians practiced rather rigid seed selection and had fairly definite standards. The ears were selected each fall before frost and the husks braided together such that a braid would contain about 50 ears. These braids were hung up to dry before being stored.

A corn secured from the Mandan Indians at Mandan, N. Dak. by Oscar H. Will of Bismark in 1882, having been grown by these Indians for at least 200 years previously, was grown extensively in the Northwest as the highest yielding corn in that area until 1935, or until higher yielding hybrids replaced it.

An Innovation

The advent of hybrid corn was the most outstanding event in Indiana farm genetics. The repeated inbreeding of corn by East and Shull, working independently, showed that the species could be analyzed, the various characters appearing in different plants in pure form. Among the various strains which appear during this process, two desirable ones are selected and allowed to cross, the resulting progeny being known as hybrid corn. According to a conservative estimate, hybrid corn yields 12 bushels more per acre than open pollinated corn, other factors being equal.

Since the principles of heredity apply to all species, breeders at once tried to secure similar improvement in other plants, and also in animals. But difficulties are encountered in that some species, wheat for instance, if crossed at all, must be pollinated laboriously by hand. Another difficulty is that much discarding is necessary in order to develop pure strains for crossing, and in the case of farm animals, this elimination is much more expensive than in corn.

The 1936 Yearbook of the U. S. Department of Agriculture contained an article entitled "Livestock Breeding at the Crossroads" (8) which was radical in that it advocated crossing of breeds. "Breeds developed for the same purpose are arbitrary division fences. . . . Their ancestors have lived for over a century in an animal society where mixing of the two germplasms constitutes a breach of etiquette punishable by condemnation to the butcher's block."

This criticism, although packed with dynamite, was ignored by the vested interests, the breeders, until the U. S. D. A. started to act upon it. They crossed pure breeds of cattle, postulating that a breed has been made similar to a strain of corn, through inbreeding and selection. Their report was that this imitation of the corn breeders was succesful; that the resulting heterozygosis resulted in greater milk yield and other improvement. But at this juncture the herd associations raised a hue and cry which has not entirely subsided even now.

A significant effort in hog breeding is being carried on by the state experiment stations. A breed of hogs is inbred at one station, another breed at another station, with the result that different strains are produced which differ greatly in merit. The few good strains which are kept for breeding are largely homozygous and uniform, and crossing with a similar strain from another breed gives an increase in vigor, comparable to hybrid corn.

The Present Situation

The principal method of animal breeding, however, continues to be the maintenance of the breeds, registering the pedigrees of individuals and mating within the breed. While the breeders have rendered a service to agriculture, their pay often is not in proportion to the amount of service given. Some of them, who are good at promotion, sell all of their males for breeding, and at a high price. But since variation is going on all the time, the inferior animals should be slaughtered lest the breed deteriorate.

On the other hand, a gifted breeder who is not so good as a salesman may not be able to sell at prices high enough to be remunerated for his work. Then he may cease to register his animals, with the result that they receive the inferior classification of grades, regardless of their true worth.

The chief tools of the breeders continues to be shows and auction sales. Often the characters by which excellence is judged have little or no real value. The writer recalls a small herd of registered hogs. Only one sow was a good mother, being very careful in lying down not to lie on a pig. But she never would have received first place in a show because she had curly hair. If the breeding stock had been selected at a show, the best sow would have been discarded.

Whether we like it or not, farm animals of the pure breeds, the ones which are registered or eligible to registry, often do not sell higher than others except in times when money is plentiful. But at an auction where much publicity has been given, pure bred animals often sell for several times as much as others, demonstrating that it is promotion rather than germplasm which attracts high prices.

But can breeders pledge that a pedigree is a reliable badge of superiority? Our best farm animals are to be found within the pure breeds but are all of the pure bred animals superior to others? This guarantee could be made if enough care had been exercised in selecting the individuals to be registered, refusing to register any but the best. Breeders who are committed to this program are public benefactors, and some method should be worked out to insure that they will be well paid.

Acknowledgments

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History of Forest Conservation in Indiana

DANIEL DENUYL

The interest of man in forest trees dates back to the dawn of mankind. Even though forest trees were growing in the garden of Eden, the fruit of them was not as tempting as that of the apple. Man's early interest in the forest was related to his dependence on the products it supplied him.

Just when man's interest began in the forests of the area we know now as the State of Indiana is not known. However, the Indians and the early explorers were much concerned with the forests because they provided many things that made possible their existence.

The first contacts of the white settlers with the forest of Indiana were such that they devoted their efforts to get rid of them. Clearing the land of trees in order to grow food was an early necessity. So the forests that were here during the settlement of Indiana were considered as a product of nature to be used, destroyed and not replaced. The forest conservation concept, the wise use of the forest, was not evident during the opening and settling of the State by white people.

The period 1800 to 1860 was the era of active settlement in Indiana. This was followed by the period 1870-1900 when cities were built, railroads were constructed and farm machinery was introduced. Consequently the forests were cut, the land put to crop use and little thought was given to the future supply of timber. It is therefore interesting to note that a few progressive people began to be concerned about the destruction of Indiana's forests. A few pioneer thinkers suggested "forest preservation" and advocated the reforestation of cut-over lands. There was considerable interest in natural resources and in 1869 the Department of Geology and Natural Resources was established in Indiana.

Chronologically the history of forest conservation in Indiana falls into four broad periods of time; (1) 1870-1900, (2) 1901-1918, (3) 1919-1932, (4) 1932-1056.

In tracing the course of forest conservation in Indiana it is very apparent that national forestry movements and other state activities greatly influenced the forest conservation activities in Indiana. The events and happenings that appeared to me to be important have been selected from the records that are available. In interpreting some of the records I have had notes and records by the late Charles C. Deam who over a period of years, gave me the benefit of his experiences in forestry in Indiana.

Unfortunately it is not possible to state exactly what did take place at certain times and the names of people associated with such events may have been omitted because the references available did not include them. There must have been those who did much to aid the cause of forest conservation but for some reason they did not leave a written record of the part that they took.

1870-1900

During this period many individuals were advocating measures that would preserve the forests. Although many of these people were primarily interested in botany nevertheless they helped lay the ground work for later and more specific plans for forest conservation. There were organized groups such as the Indiana Horticultural Society, Indianapolis Academy of Science, Indiana Academy of Science, State Board of Agriculture and Farmers Institutes that helped promote interest in forest conservation. To illustrate how the concept of forest conservation was developed a few examples are presented. Forestry subjects reported in the transactions of the Indiana Horticultural Society which typify the period were:

1871—Tree Planting—T. Montgomery
1876—Artificial Timber Production—Prof. J. Hussey
1877—Sanitary Influence of Forests—George L. Andrews
1880—Trees—John A. Warder
1890—Forestry—B. E. Fernow
1894—Resolutions on Forestry—John Coburn
1898—An Enlarged Forest Area a Necessity to the State—J. P.. Brown

Two references from the Indiana State Board of Agriculture reports also indicate the interests of the period; 1881 Forestry—Prof. C. L. Ingersall, 1889 Forests and Droughts by Daniel M. D. Berry. The influence of the Indiana Academy of Science in the forest conservation movement during this period was expressed by the activities of John M. Coulter, Stanley Coulter, E. C. Pegg, Will Scott, W. P. Shannon, M. B. Thomas, Guy Wilson and John S. Wright.

Events were taking place on a national scale and outside stimulus came from the organization of the United States Department of Agriculture in 1862. The American Association for the Advancement of Science in 1873, "Memorialized Congress and the Several State Legislatures on Preservation of Forests." National movements that must have influenced forest conservation in Indiana occurred in 1875 when the American Forestry Association was organized in Chicago, Illinois; in 1882 when the first American Forest Congress was held in Cincinnati, Ohio; in 1891 when the President of the United States was given power to establish forest preserves; 1897 President G. Cleveland proclaimed over 20 million acres of new national forest reserves.

Some of those associated with these national events were B. E. Fernow, F. B. Hough, John A. Warder, Warren Higley and Baron Von Steuben. They dramatized the need of forest conservation, they organized groups of interested people and outlined programs of action. Although the records do not show Indiana men as leaders of national movements nevertheless men like Stanley Coulter, John M. Coulter, John P. Brown and others were aware of national events and were encouraged by these to continue their efforts in Indiana. This period from 1870 to 1900 could be called one in which "building forest conservation sentiment" was developed.

1901-1918

Public sentiment toward forest conservation took form on March 1, 1901 when the Indiana State Legislature established a State Board of Forestry. The provisions were that, "It shall consist of five members who shall be appointed by the Governor as follows: One from the membership of the State Forestry Association, one from the membership of the Retail Lumber Dealers Association of Indiana, one from the faculty of Purdue University, one from the woodworkers of the State and one who shall have special knowledge of the theory and art of forest preservation and timber culture and technical knowledge of the topography of the State, and said last described member shall, upon his appointment and qualification, become and be the secretary of said board and ex officio State Forester." The five members of the board were: Albert Lieber, Indianapolis, President; John Cochrane, Indianapolis; S. P. Carson, Michigan City; Stanley Coulter, Lafayette; and W. H. Freeman, Indianapolis, Secretary.

Apparently the act as passed wasn't entirely suitable because in 1903 it was revised. The membership representative from the woodworkers of the State and the State Forestry Association were deleted and in their place specified a member from the "Hardwood Lumber Dealers Association and one who is actively engaged in farming." The five man board known as the State Board of Forestry functioned from 1901 until 1919 when the Conservation Department was organized.

It is interesting to note that when the State Forestry Board was set up in 1901, the State Forestry Association was to have one of its members on the board. In 1903 the State Forestry Association member was deleted from the board. Unfortunately other references to the State Forestry Association were not found and the question arises, "Was this association active in 1901, in 1903 and in later years?"

In all my discussions with the late Charles C. Deam, who was well acquainted with the history of forestry in Indiana, no mention was made of a State Forestry Association. Deam put together a bibliography on forestry in Indiana which was published in the 1910 report of the State Board of Forestry. It did not contain a reference to the State Forestry Association. This bibliography was freely used in preparing this paper.

In 1903 the State Board of Forestry was empowered to buy 2,000 acres of land in any county or counties for a forest reservation, laboratory of forest demonstration and state nurseries at $8 or less per acre. The board, after considering 30 offers, decided to buy the tract offered by Dunlevy and Freeman of Henryville, Indiana. Funds for the purchase came from Governor Durbin's contingent fund. The tract was located in the northwestern part of Clark County and consisted of 20 old farms. The price paid for the land varied from 21 cents to $38.79 per acre. It was part of the 150,000 acres given to General George Rogers

Clark and his men for their part in capturing Vincennes from the British. The forest reserve is now called the Clark State Forest, the present area of the forest is approximately 18,000 acres.

In 1905 forest fire laws were enacted but little was accomplished by these laws. Local prosecuting attorneys failed to prosecute the violators.

Arbor Day was officially designated in 1913. A year later, in 1914, forestry courses were started at Purdue University. Stanley Coulter, Dean of the School of Science secured the services of B. N. Prentice, a forestry graduate, to teach the courses.

The progress of forest conservation in Indiana during this period is well illustrated in the annual reports of the State Board of Forestry. In these reports are records of contests and essays to promote forestry, progress reports of board activities, reports on forestry problems of Indiana, the work of the State Forester, and the results of experiments in forestry on the Clark State Forest.

Under Charles C. Deam's leadership many experiments in tree planting and forest culture were initiated on the Clark Forest. Others who did much to promote forestry in the state were Stanley Coulter, a member of the State Forestry Board who wrote about woodlot conditions in Indiana; Glen Culbertson, who wrote about tree planting problems and forest land use problems. Another person who made contributions to the forestry movement was John P. Brown of Connersville, Indiana. He advocated tree planting and his interest in tree planting led him to publish a book, Practical Arboriculture, in 1906, and a magazine, Arboriculture. This magazine published from 1902 to 1909 was widely read and did much to promote tree planting. Perhaps the era of catalpa planting was largely due to Brown's efforts and he was given much publicity assistance by the leading farm papers.

National events that occurred during the period 1901-1918 also helped promote forest conservation in Indiana. Perhaps the greatest stimulus came in 1905 when President Theodore Roosevelt addressed the Forest Congress in Washington, D. C. Another one who took an active part in the Forest Congress was James Wilson, Secretary of Agriculture, who was the deciding influence in the establishment of the United States Forest Service. Other developments during this period were: changing the National Forest Reserves to National Forests in 1907; the white house conferences of governors in 1908; passage of the Weeks Law in 1911. Although these acts did not relate directly to Indiana nevertheless they did indirectly influence its forest conservation progress.

1919-1932

This period began with the organization of the Indiana Department of Conservation. The act was passed in 1919 and provided for a Conservation Commission of four members. That the Indiana Academy of Science was recognized is illustrated by a clause in the act which states that, "at least one member of such commission may be appointed by the Governor from a list of persons nominated by the Indiana Academy of Science and the successors of such appointee may in like manner be so nominated and appointed." Was this part of the act changed or has the Academy failed to exercise its influence? The first conservation commission was composed of W. A. Guthrie, DuPont; John W. Holtzman, Indianapolis; Stanley Coulter, Purdue University; Richard Holman, Wabash.

Another event which stimulated much interest in forestry was the Tri State Forestry Conference held in Indianapolis in 1919. The States of Illinois, Ohio and Indiana were represented by forestry interests and "forestry experts," at the conference were: H. S. Graves, Chief of the United States Forest Service; J. G. Peters, Chief of State Cooperation, U. S. Forest Service; R. B. Miller, State Forester of Illinois; Edmund Secrest, State Forester of Ohio and I. C. Williams, Deputy Conservation Commissioner of Pennsylvania and Charles C. Deam, State Forester of Indiana.

Through the efforts of State Forester Deam, who was ably assisted by Oliver P. LaFuze, representative for Wayne and Union Counties, in the legislature, the Forest Land Tax Reduction Act, (commonly known as the Classification Act) was enacted in 1921. This provided for assessing forest land at one dollar per acre providing it is maintained as a forest and protected from livestock grazing.

A real step forward took place in 1925 with the enactment of the LaFuze Law which provided tax money to be used for forest land purchase, maintenance, and fire protection.

In 1926 forestry instruction given in the School of Science at Purdue University was transferred to the School of Agriculture. A four year course in forestry was initiated at this time with Professor B. N. Prentice as Head. In addition to forestry instruction experimental forestry research projects were started in woodland management and utilization. Four years later, in 1930, a forestry extension program was started at Purdue University in cooperation with the Indiana Division of Forestry.

Some other events of the period which were a stimulus to forestry were as follows:

1923—Organization of Central States Section—Society of American Foresters.
1924—State Forestry Conference in Indianapolis.
1924—Clarke-McNary Act (Federal Cooperation with States).
1928—Central States Forest Experiment Station (U. S. F. S.) at Columbus, Ohio.
1930—Central States Forestry Conference in Indianapolis.

The year 1929 saw the addition of the Morgan-Monroe State Forest. The area was purchased by the State and prior to this time the Clark State Forest was the only State Forest operated by the Division of Forestry.

1932-1956

The establishment of the Civilian Conservation Corps in 1933 marked the beginning of a period of accelerated forest conservation activities in

Indiana. The Soil Erosion Service was also organized that year and the influence and activities of these agencies extended to all parts of the state. The work programs of these agencies centered around tree planting to control soil erosion, woodland improvement and other related activities. Work camps were established on State Forests and forest improvements, tree planting and woods improvement constituted part of the camp program.

The lumberman was also brought into the forestry movement in 1933 by Article 10 of the National Recovery Act. Although the act was declared unconstitutional it did bring together the lumberman, the wood using industries and forest conservationists. Better working relationships between these groups grew out of this movement.

The year 1935 saw the beginning of the land use programs such as Rural Resettlement, Soil Conservation Service, and the Hoosier Purchase Unit. Two of these agencies, the Rural Resettlement and Hoosier Purchase Unit had as their major purpose land purchase.

Even though these federal agencies competed with each other and with the State of Indiana in land purchase nevertheless a considerable acreage of submarginal land was placed in public ownership. The land purchase activities certainly focused attention on land use problems and the need for action that would rehabilitate both the people and the "worn out" land.

Along with federal activities in land purchase, land acquisition for additional State Forests was accelerated. The following State Forests were acquired during this period: Ferdinand, Jackson, Harrison, Scales Lake (transferred to Parks in 1951), Greene-Sullivan, Pike, Martin, Francis Slocum, Salamonie River. The Selmier Forest was a gift to the State by Frank Selmier and the Yellowwood Forest by transfer from federal to state ownership. The Wells County Forest was also purchased during this period, but later transferred to the Fish and Game Division. Cagle Mills State Forest, the most recent purchase, was transferred to the Parks Division, now Cataract Lake State Recreation Area.

In 1937 the federal Norris-Doxey farm forestry act was initiated. This act provided financial assistance to the state in order to stimulate interest and carry out a farm forestry program. Expansion of activities relating to farm woodlands in Indiana followed and its influence continues to be evident at the present time.

It wasn't until 1941 that legislation was enacted pertaining to strip-mine coal lands. The act passed by the legislature represented a joint effort on the part of the coal land owners and forestry interests to formulate and carry out a program for the revegetation of the spoil banks. The law was amended in 1951. The law is still in effect and most of the stripped coal lands have been planted to trees.

With the advent of World War II, work of the Civilian Conservation Corps was terminated. This program which was active from 1933 to 1942 left a real mark on Indiana's landscape. Many forest conservation lessons were learned through the efforts of the C.C.C. This activity exerted a greater influence on forest conservation in Indiana than any other event that has taken place since the beginning of forest conservation.

During the war period Indiana's hardwoods furnished many essential wood products. Its land area was also effected by military land purchases of both forest and agricultural lands. Many of these areas are still being used for military purposes.

Immediately following the close of World War II nine new state forest districts were set up and staffed with district foresters. Forest tree nurseries were also expanded and the State Division of Forestry began an enlarged program of activity. At the same time the Purdue University Extension forestry program was expanded by the addition of 4 district extension foresters.

Curtailment of the activities of the State Division of Forestry took place in 1952, the number of district foresters having been reduced to four.

The most recent event in Indiana's forest history took place in August, 1956 when the National Tree Farm Program was initiated. Dedication ceremonies took place in DuBois County. This marks another forward step in which forest industries and woodland owners cooperate to wisely use and perpetuate Indiana's forest resources.

Summary

The major events in the history of forest conservation in Indiana show that in each period certain individuals left published accounts of their activities, while others did not record their activities. From the record of those who were associated with the forest conservation movement, two names are most prominent, Stanley Coulter and Charles C. Deam.

Stanley Coulter was on the first State Board of Forestry and also on the first conservation commission, serving on these two boards for 32 years. He remained interested until his passing in 1943.

Charles C. Deam became State Forester in 1909 and except for a brief period he continued in that capacity until 1929. He remained active until 1940 and very influential until his passing in 1953.

Those who served the forest conservation cause and who have passed on were: John P. Brown, John M. Coulter, Glen Culbertson, W. P. Freeman, Richard Lieber, O. P. LaFuze, T. E. Shaw and John S. Wright.

Those who are still active in forestry and who have been associated with the movement for many years are Professor B. N. Prentice, in educational work at Purdue University since 1914 and R. F. Wilcox who joined the Division of Forestry in 1926. He served as State Forester from 1929 to 1935 and was appointed again in 1946. He is now serving as State Forester.

Conservation of Recreational and Scenic Resources

HOWARD H. MICHAUD, Purdue University

Introduction

The concept of preservation of a natural area for recreational use, or for its scenic value, seems a paradox to many people. Natural resources are commonly thought of only in the sense that they yield material products. That state and national parks should remain inviolate, its forests uncut, its wildlife protected,—in fact, all commercial exploitation to be forbidden is not universally appreciated.

It is true that our civilization thrives on effective use of material resources. But the need for satisfying spiritual values is just as great. Recreational lands set aside as parks yield the great cultural and inspirational products of knowledge, refreshment, and esthetic enjoyment equally needed by all people.

Mission 66, a name applied to a long-range plan for the National Parks, describes the function of the parks as follows:

"As our vacation lands, they bring enjoyment and refreshment of mind, body, and spirit to millions of Americans each year.

"It is the history of America and if its youngsters could but journey through the whole system from site to site, they would gain a deep understanding of the history of their country; of the natural processes which have given form to our land, and of men's actions upon it from distant prehistoric times."

For those who must ascribe an economic value to all resources, parks do contribute materially to the national economy. The American Automobile Association calls the parks the primary touring objective of the American public. The unique situation of the National Parks is that while we preserve them and use them for their inherent, noncommercial values, they are contributing directly to the economic life of the Nation.

It is a lasting tribute to the far-sighted individuals of Indiana who recognized these same values in establishing our system of state parks. The general philosophy regarding natural and scenic areas permeated the policies for administration of parks from the outset. In spite of the vicissitudes of Indiana politics we are fortunate that these policies have been fundamentally adhered to in forty years of park history.

Colonel Richard Lieber, first director of the Indiana Department of Conservation, in an address delivered to the Ohio Valley Regional Park Conference, Wheeling, West Virginia, in 1928, defined a state park as "a typical portion of the States' original domain; a tract of adequate size, preserved in primeval, unspoilt, 'unimproved,' or 'beautified' condition. It is a physical expression of life, liberty, and the pursuit of happiness."

"A state park must have either scenic or historic value or both, . . . and is dedicated to the public for the intelligent use of its leisure time."

"No, our parks and preserves are not mere picnicking places. They are rich store-houses of memories and reveries. They are guides and counsels to the weary and faltering in spirit. They are bearers of wonderful tales to him who will listen; a solace to the aged and an inspiration to the young."

"And if all that is true of the present, what will it not be in the future? When the congestion of an ever-increasing population in those days has changed everything but these primitive places, our state parks will be one of the most priceless possessions of our people."

Colonel Lieber steadfastly held to his original policies of charging a modest admission, protecting the natural terrain and values, developing wisely and providing necessary facilities as funds became available. He believed the parks should be as nearly self-supporting as possible without becoming a burden to the taxpayer. Likewise, he was strongly in favor of providing facilities for camping, accommodations for families in cabins and inns. He firmly believed that it was desirable for families to enjoy vacations together and that the cost of facilities should be cheap enough to serve all who wished to enjoy the out-of-doors.

The 1925 annual report of the Indiana Department of Conservation published a talk entitled, "What Is A State Park?", presented to the first Regional Conference for State Parks at Clifty Falls, by Col. Lieber. He said, "State Parks offer much to all classes of citizens. To the city dweller they bring the solace of quiet and solitude. In the same place the rural people may find the pleasure of crowds and intercourse with strangers, the student finds much to study in the flora, fauna, and geologic structure, the artist finds beauty, the young find the sport of swimming, hiking, and fishing and the beneficence of nature gives to each who comes what he wishes. Likewise, the park demands of its visitors that they do not destroy or mutilate its beauty and wealth, that they only take away with them the impression received."

History of Early Park Acquisition

The original agitation for setting aside areas for state parks was part of a national movement. Stephen T. Mather, Director of the National Park Service, 1915-1928, was subjected to pressures from many quarters to endorse areas for national parks. In a single year, 1916, sixteen bills for new national parks went before Congress. Mather knew what national parks should be,—he favored only areas large enough, primitive enough, and/or unique enough. He wanted to add suitable sites but also to keep out unsuitable ones.

It was largely because of the pressures for new National Parks at this time that Mather plugged for state parks. It was through the organization of the National Parks Conference that he became acquainted with many state leaders who were prominent at the time in the state park movement. He held in high esteem such men as Colonel Lieber and Tom Wallace, editor of the Louisville Times. Mr. Wallace was a member of the Board of Directors of the National Conference on State Parks, and with Colonel Lieber, founded the Ohio Valley Regional Conference on State Parks in 1924.

Many other prominent Indiana citizens joined in the action to establish park areas. Edward Barrett, State Geologist, in the annual report of the Indiana Department of Geology in 1916 said that he had been advocating the preservation of natural areas for state parks for more than six years. He also stated that he had delivered more than one hundred illustrated lectures on areas that should be preserved for their picturesque, scenic value. In 1915, Honorable Samuel M. Ralston, Governor of Indiana, appointed a State Park Commission and in 1916 they took over two tracts of land on behalf of the State of Indiana, namely, "The Canyon of McCormick's Creek," and "Turkey Run."

This marked the beginning of state parks for Indiana. Dean Stanley Coulter, eminent scientist and Dean of the Science School at Purdue University, was a member of the first Conservation Commission appointed in 1919. Dean Coulter was a prominent figure in the early park development and in an address to the first Ohio Valley Regional Conference on State Parks at Clifty Falls in 1925, his feeling for parks was revealed in these words:

"Whether it was wrought out by abstract reasoning, or was a feat of intuition, or sounded deep in some primal instinct, the park system, State and National, was inaugurated; and soon, startlingly soon indeed, we began to realize that scenery—our rivers and lakes, our hills and mountains, our fertile plains and forests, our peaks of privilege, whence we could see great vistas and glowing sunsets and myriad stars—is our greatest natural resource."

The acquisition of parks was not without a struggle. The battle for Turkey Run was a bitter first engagement and was won only because of the patient plodding of a group of men and women whose heroic efforts served to usher in a new epoch in conservation.

In 1915, a small but determined group, composed of Richard Lieber, Juliette Strauss, Dr. Frank B. Wynn, Sol S. Kiser, and Leo M. Rappaport, conceived the idea of raising a fund by popular subscription to be used for the purchase of Turkey Run and to present the property to the State of Indiana the following year as a centennial gift. The estate, it was known, was in the process of settlement and would be offered at public auction the following spring.

In spite of the efforts to interest people throughout the state, it was soon found that it would be necessary to start the process of fund raising in Indianapolis. The project was presented to a group of business and professional men called together at a luncheon at the Commercial Club of Indianapolis. Due to a lack of immediate response one of the members of the original group made the first offer to subscribe $100. The offer was criticized by another man in the group as setting a pace too high. After considerable debate, Mr. J. D. Adams who had been reared near Turkey Run, stated that under all circumstances the property should be acquired and that he was willing to contribute $500.

Thus, the ice was broken and the committee with this start eventually succeeded in raising $20,000.

The auction was conducted in April, 1916. Lumber dealers had been requested to withhold bidding. The Committee felt that they had a clear course and would have sufficient funds to pay for the property. However, such was not the case, and after spirited bidding the property was sold for $30,200 to an individual representing a lumber company who wanted it solely for commercial use of the valuable timber.

Undaunted, the Committee began immediate negotiations with the purchaser, who offered to surrender it after it had been stripped of its good timber. This offer was naturally rejected. Later, the company offered to sell the property intact, at an advance of $10,000.

The Committee set to work immediately to raise more funds. In October, 1916, the Committee succeeded in interesting Mr. Carl Fischer to spend a day visiting the area. Mr. Fischer was tremendously impressed and very generously offered to donate $5,000. Moreover, he was successful later as a member of the Board of Directors of the Indianapolis Motor Speedway, to persuade them to donate ten percent of the proceeds of the next Memorial Day Race. Furthermore, Mr. Arthur Newby, another member of the Board of Directors, made a personal contribution of $5,000.

With these funds and an appropriation of the General Assembly of 1917, the Committee was able to complete the purchase of the property, and on November 11, 1916, signed the papers for 288 acres which constituted the original acreage at Turkey Run.

Such were the beginnings of the highly competitive struggle for land to be used by the people of our state for recreational use.

A Long-Range Program for Parks

In 1944, Charles A. DeTurk, Director of the Division of State Parks of Indiana said, "In all probability the State Parks of the future in Indiana will follow the pattern set by the last twenty-eight years of experience in this field."

This statement served as an introduction to a proposed plan for future park development and a re-appraisal of past policies. Following the original concept of state parks, the plan set forth definite standards applicable to the establishment and development of new areas. These were:

(1) To preserve and protect for present and future generations areas of the finest remaining, natural, unspoiled scenery of the state.

(2) To provide outdoor recreation,—opportunity for the public to enjoy, use and live for a while upon the land that is, in the truest sense, their own.

(3) To preserve or commemorate some of the state's historical background, or some of its people whose lives have affected the history or culture of the state. So, in this way to create respect and pride in our state, as well as encouragement and inspiration to future generations.

The meaning of outdoor recreation as related to the parks was defined. Its true meaning was to recreate the body, mind, and spirit of man. The popular meaning of organized exercise through games was not intended. Appreciation of scenic values was emphasized as subjective,—inspirational because of the spiritual value of the scenic features of the parks.

In order to follow the standards set forth in the plan it was necessary to recognize first that prominent scenic or historic areas had to be acquired where they existed, regardless of geographic location. Secondly, true recreation areas had to be planned with geographical and population factors as paramount considerations. Consequently, if the plan was to be based on these premises, it was important to give careful consideration to the natural features of the state which could meet the necessary requirements. The following is a brief resume of that portion of the plan which suggested special areas for consideration:

(1) To determine the prominent scenic areas available that would include representative Hoosier geographical and physical types of landscape that should be preserved. It was suggested that all areas to be considered should be at least 1,000 acres in extent and should be surrounded by buffer strips for protection in which good forestry and wildlife practices could be maintained. Areas suggested included:

a. An unspoiled natural lake area in north central Indiana.

b. Fifty to one hundred miles of outstanding Indiana waterways, including both banks, and sufficient acreage to constitute an administrative unit. Rivers mentioned were the Tippecanoe, Mississinewa, Wabash, Whitewater, and Sugar Creek.

c. An area in the upland, glaciated, gently rolling land between Fort Wayne and Richmond east of Indianapolis.

d. An area on the bluffs of the lower Wabash river, preferably in connection with the New Harmony Memorial.

e. The superb hill and timberland and caves in the Wyandotte Cave area.

f. One typical and natural prairie area in northwest Indiana in Lake, Newton, or Benton Counties.

(2) To determine by geographical and population maps the need for recreational areas to better serve the Indiana public in its heavily populated centers. The plan visualized a state park located within easy driving range of every community of the state. Population concentration centers mentionad included: the Calumet area, the South Bend area, the Logansport-Peru-Rochester area, the Fort Wayne area, the Lafayette area, the Marion-Muncie-Anderson area, the Indianapolis area, the Richmond area, the Evansville area, the Vincennes-Washington area, and the Louisville-New Albany-Jeffersonville area.

(3) To determine the historical areas, buildings or communities that have a definite, significant and important effect in the progress and development of Indiana and its people which are in present or ultimate danger of destruction. Examples of state-wide significance mentioned were: the New Harmony Community; old canal systems such as the Whitewater and Wabash-Erie; residences of historical

importance included the Gene Stratton Porter, James Whitcomb Riley, and William Henry Harrison homes; structures in Vincennes of the Indiana territory era; an original tavern, the Halfway House, on old pioneer road 40; the Bright Angel Mounds near Evansville, representing an area of outstanding Mound Builder culture; the Frances Slocum area as an example of Indian culture; and the development of a "Trading Post" center.

The remainder of the plan was devoted to a general development scheme that would provide facilities for access and use-areas to accommodate public enjoyment compatible with the objectives for properly preserving the natural, cultural, esthetic and historical values inherent in the properties.

Present Status of State Parks as Recreational Areas

From a modest beginning of two state parks in 1916, the present system under the Division of State Parks, Lands and Waters includes sixteen state parks, two state beaches, and one state recreation area. Many of the proposed additions outlined in the 1944 plan have been acquired. The properties added during the last ten years are Cataract Lake State Recreation Area (1956), Kankakee River State Park (1947), Scales Lake State Beach (1951), Shades State Park (1947), and Whitewater State Park (1949).

The present acreage of the state parks and memorials in Indiana is 49,801 acres. An appraisal of the total land value of state parks, estimated as of June 30, 1955, was $4,959,049.66, and the value of improvements and structures was $13,533,922.24, making a total of $18,492,971.90 in the estimated value of the state park system. This figure was increased by approximately $500,000 in 1956, bringing the total evaluation to nearly $19,000,000.

The importance of parks as a recreational and economic asset to the people of our state cannot be denied. Mr. Kenneth R. Cougill, Director of the Division of State Parks, Lands and Waters, in an article in Outdoor Indiana, August, 1951, said, "Administrators throughout the thirty-five years of Indiana State Park history have adhered to sound basic policies of management. Perhaps the most important of these is the recognition that state parks are for all the people and no special interests are served."

Due to effective planning and setting high standards the parks have served Indiana citizens well. The fact that parks have charged a nominal admission fee since 1919 has proven a sound practice for helping to provide suitable facilities for recreational use. It has also abetted a fundamental conservation principle that the areas must be maintained without deterioration through use. That use has not been discouraged because of it, is proven by attendance figures. Paid admissions have steadily increased from 1919 with a total of 33,144 initially collected at Turkey Run to a total of 2,003,718 during the fiscal year 1955-1956 derived from admissions to our parks, beaches and recreation areas.

Future Plans for Additions of Land and Facilities

Because of an expanding population and more abundant means of transportation, the pressure for recreational areas is constantly increasing. New locations and facilities will be needed and planning must attempt to keep ahead of the public demand.

New properties now under consideration include a Chain O' Lakes State Park in Noble County, south of Albion, which will provide swimming, fishing, boating and picnicking. The Mansfield Flood-Control Project, now under construction in Park County on Raccoon Creek, is expected to make available a 2,000 acre area to be known as the Raccoon Creek State Recreation Area.

New campgrounds are planned for Whitewater and Lincoln State Parks and for the Cataract Lake State Recreation Area.

Conservation Values of State Parks

One of the basic rules of state parks is that "No person shall injure, destroy, remove, mutilate or deface any building, structure, sign, rock, tree, shrub, vine, or property whatsoever, nor pick any flowers, nor take, kill, injure, pursue, hunt or molest or rifle the nest of any bird, or the den, nest or abode of any wild animal: Provided, that flowers and leaves may be gathered in small quantities for scientific and educational purposes upon written permission of the Indiana Department of Conservation."

Our parks have, in keeping with the original concept, preserved areas in primeval, "unspoilt" condition, in spite of extensive use. They have provided scientists these many years with areas of untold value for the study of flora, fauna and geological structures. An abundance of literature pertaining to the state parks has added significantly to the scientific knowledge of the state.

The conservation of scenic and recreational areas as state parks in Indiana can be strongly justified for the spiritual and cultural satisfaction alone which they have offered to our people. While they also contribute economic benefits to the local communities by way of tourist's trade, their intangible values in outdoor education and recreation are immeasurable. These are the treasures that we as conservationists must esteem above all else.

A History of the Study of Fishes in Indiana

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Introduction

Fishes have provided a wide variety of research material bearing on taxonomy, evolution, distribution, life history, general ecology, and the analysis of populations. Studies made in Indiana have contributed significantly to all of these subjects since the early history of ichthyology in the United States. In fact, Indiana University was a center of ichthyological interest in the years between 1875 and 1925. The tradition has been maintained, and there has been an unbroken chain of biologists interested in fishes from the days of David Starr Jordan to the present. These men have concentrated on basic biological problems, and the results of their researches have had far-reaching effects on the development of ichthyology and fishery biology.

As in most other fields of biological inquiry, the first studies were directed toward taxonomy and anatomy. The work of the present day is built upon a fine foundation laid by the early naturalists in these fields. Concurrent with the descriptive studies, research on fishes received a stimulus from another quarter. Commercial and sport fishermen alike were aware that fish populations fluctuated considerably from time to time. Large variations in the catch demonstrated this fact beyond any question. Also, great differences were found in the productivity, species composition, and the size of fishes which were caught in different places. The questions which were raised by these observations required explanation, especially since a great economic importance was attached to them. Knowledge was needed about the nutrition, physiology, diseases, behavior, age, growth, and population characteristics of fishes in order to utilize this resource intelligently. The work has become a fascinating field of scientific endeavor, and it is being prosecuted vigorously throughout the country.

The Earliest Records

The first records of the fishes of Indiana coincided with the entrance of the state into the Union. There were only a few colonies of people, scattered principally along the Ohio River, when the first constitutional convention was held at Corydon in 1816. In 1820 the capital was moved to Indianapolis, and Samuel Rafinesque's "Ichthyologia Ohiensis" appeared the same year. Rafinesque's untoward adventures have been recorded elsewhere, and it is not the province of this paper to repeat them. Suffice it to say, that he took a trip down the Ohio Valley in 1818, a year before he was appointed to a professorship at Transylvania University in Lexington, Kentucky. His excursion into Indiana was at the Falls of the Ohio River near Jeffersonville where he hastily described about a hundred new species. In typical fashion Rafinesque preserved no type specimens, and ichthyologists were left to wonder what he actually saw. In later years David Starr Jordan revisited the site, and he was able to save much of Rafinesque's work for posterity by comparing his collection with Rafinesque's descriptions. On the same trip Rafinesque went as far west as Illinois and visited the Wabash River on the way. This accounts for the references to Wabash River species which are found in his famous paper.

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[1] Contribution Number 505 from the Department of Zoology, Indiana University, Bloomington, Indiana.

Rafinesque was a visitor to New Harmony on the Wabash River in southwestern Indiana after Robert Owen from New Lanark, Scotland, purchased the settlement from a religious group, the Rappites, in 1824. The famous "Boatload of Knowledge" from Pittsburgh in 1826 brought a group of distinguished scientists to participate in the well-known but unsuccessful social experiment. Included among them were Thomas Say, the Father of American Zoology, who will always be remembered for his studies on the shells and insects of the region, and the great French ichthyologist, C. A. LeSueur. LeSueur had done much exploratory work in the eastern United States and Canada before coming to New Harmony. With this background and further work in the Middle West he wrote his great book, "American Ichthyology. Or, Natural History of the Fishes of North America: with Coloured Figures from Drawings Executed in Nature," which was published in New Harmony in 1827. The "Histoire Naturelle des Poissons" by Cuvier and Valenciennes referred briefly to Indiana fishes in 1833. They did no collecting in this country but relied on information gathered by LeSueur.

Later on as the country became more settled, the interest in natural history grew. The contributions of physicians were among the most important of the early period. Jared P. Kirtland, who made valuable discoveries in Ohio, studied some of the Indiana tributaries of the Ohio River, and reported his findings in 1841 in the *Boston Journal of Natural History*. Another physician, J. T. Plummer, made collections around his home in Richmond, and the list of fishes which he found was printed in the 1851 volume of the *Proceedings of the Boston Society of Natural History.*

The famous naturalist and paleontologist, Edward Drinker Cope, visited Indiana in the 1870's. He was especially interested in the cave blindfish, *Amblyopsis spelaeus*, and visited Wyandotte Cave near Corydon in southern Indiana in order to see the species in its native habitat. The 1872 volume of the *Annual Reports of the Geological Survey of Indiana* carried his article, "Life in Wyandotte Cave."

Jordan's Day

A great surge of interest in fishes accompanied the arrival of David Starr Jordan in the state. He had spent two years of teaching since receiving his M. S. degree at Cornell, one at Lombard College at Galesburg, Illinois and the other at the Appleton Collegiate Institute, a preparatory school in Appleton, Wisconsin. After the latter appointment he joined the faculty of Shortridge High School in 1874 and a year later became Professor of Biology and Dean of Science at Butler University, a position which he held until 1879.

Botany, ornithology, and geology had claimed his attention in his collegiate years, and his field of specialty was undecided. During a summer with Louis Agassiz at his summer school on Penikese Island off the coast of Massachusetts, Jordan was given the project of collecting and identifying the fishes of the region. This must have made a considerable impression on him because he continued work along these lines at Appleton.

In Indianapolis he and Herbert E. Copeland, a colleague from Cornell, began to study fishes in earnest. It was quickly apparent that the dean of North American ichthyology was at work. Jordan could hardly wait to get started on his life's work, and one of his first papers was "Genera to be looked for in Indiana." This and two papers on the cosco *(Leucichthys artedi)* of Lake Tippecanoe appeared in 1875. He and Copeland began three sets of investigations; the life history of certain species of darters, the identification of the fishes described from the Falls of the Ohio by Rafinesque, and a catalogue of the freshwater fishes of the United States. The latter project indicated the broad scope of the work which he intended to carry on during his life. In addition, the two collaborators collected 69 species around Indianapolis. No laggard about publication, Jordan appended the list to a comprehensive paper, "Partial Synopsis of the Fishes of Upper Georgia with Supplementary Papers on Fishes of Tennessee, Kentucky, and Indiana," in the 1877 *Annals of the New York Lyceum of Natural History.* He acknowledges that the fish were collected by Professor H. E. Copeland and himself, but it was not until 1882 that the same list appeared under joint authorship in the *Reports of the Geological Survey of Ohio.* Three other papers concerning Indiana fishes also appeared in Jordan's name in 1877.

Jordan's interests were too broad for Indiana's fishes to occupy his full attention. After writing a catalogue of the fishes of Indiana in 1877, he compiled a catalogue for Illinois in 1878, and one for Ohio in 1882. His restless search for new species continued as long as he lived. In 1876 he explored the streams of Georgia with Charles Gilbert, who became a life-long associate and a brilliant ichthyologist in his own right. He again went south in 1877 and 1878, and this time Gilbert, A. W. Brayton, and Barton Warren Evermann accompanied him. These trips were made on foot and one cannot help but admire the persistence and devotion of these men to their work. Several papers on taxonomy grew out of these trips. One of the best was published as a *Bulletin of the U. S. National Museum* in 1878 with Alembert W. Brayton, "On the Distribution of the Fishes of the Allegheny Region of South Carolina, Georgia, and Tennessee with Descriptions of New or Little Known Species."

During this time Jordan became acquainted with the curators of the National Museum where he visited frequently. With financial help from the Museum he was able to visit every major river basin in the

United States by 1890. He knew the taxonomy of fishes better than any man of his day and perhaps of the present day also. At least no one has had the courage to tackle a revision of "The Fishes of North and Middle America" which began in the days in Indianapolis with Copeland, was continued with Gilbert as the "Synopsis of the Fishes of North America" in 1882, and brought to a conclusion with Evermann in 1900.

Jordan joined the Indiana University faculty as Professor of Natural History in 1879, and quickly became recognized as an outstanding teacher. One of Jordan's greatest attributes lay in his ability to attract superior men to his fold and bring them to full flower. Quite naturally these men became interested in fishes. Evermann and Gilbert have already been mentioned. Evermann distinguished himself with the U. S. Fish Commission and later as Curator of the Division of Fisheries of the U. S. National Museum and as Director of the Museum of the California Academy of Sciences from 1914 until his death. Charles H. Gilbert received his original indoctrination in ichthyology on Indiana fishes before following Jordan to Stanford University where his work on Hawaiian fishes and the salmon and trout of the West Coast became recognized the world over. Joseph Swain, a mathematician, fell under Jordan's spell and he described a new species of darter from southern Indiana. Later Swain became president of Indiana University from 1893 to 1902 and left Indiana to become president of Swarthmore College in Pennsylvania. Oliver P. Jenkins, Amos Butler, Albert B. Ulrey, Stephen A. Forbes, and the great paleontologist Oliver P. Hay all worked on Indiana fishes in Jordan's time. These men received at least the A. M. degree from Indiana University and most of them were awarded the Ph.D. degree. Hay ultimately published, "The Lampreys and Fishes of Indiana" in the 1894 *Report of the Indiana Department of Geology and Natural Resources.*

Indiana is the birthplace of another distinguished ichthyologist, John Otterbein Snyder. His early education was received in the state and he attended Indiana University for a year. Snyder completed an A. M. degree at Stanford in 1899 and went on to become the head of the Zoology Department at that University from 1925 to 1932. He also served the U. S. Fish Commission, the U. S. National Museum, and the California State Fish and Game Commission. He was the Director of the Bureau of Fisheries Laboratory at Woods Hole, Massachusetts for many years.

Eigenmann's Day

Carl H. Eigenmann was one of Jordan's favorite students who took over ichthyological work at Indiana University after Jordan left the presidency of the University in 1891 to become president of Stanford. Eigenmann was head of the Zoology Department from 1891 to 1925, and the first Dean of the Graduate School from 1908 to 1925. His Bachelor's, Master's, and Doctor's degrees were all obtained from Indiana University between 1886 and 1889.

In 1886 he went to California to take a job in the public schools of Santa Paula. He failed to arrive in time to get the position and continued on to San Diego where he married Rosa Smith, another of Jordan's students, who was an avid naturalist. The couple then travelled to Harvard and spent two years working on the South American fish collection. They returned to an Diego, and Eigenmann became Curator of Fishes in the Museum of the San Diego Society of Natural History. During this time the two published papers as joint authors, and throughout their life together the wife and husband worked closely on many scientific enterprises. Eigenmann made extensive explorations of the marine and freshwater fauna of the western United States while he was in the west, and in 1892 collected fishes along the line of the Canadian Pacific Railway for the British Museum.

Eigenmann is chiefly known for two great pieces of work, studies on the cave vertebrates and the taxonomy of South American fishes. The latter work was his first love and he published continuously on the subject throughout his career. He became acquainted with the tropical fauna by visiting the major eastern museums which had accumulated collections from various expeditions to South America. He rapidly became an expert on the region. His first publication on these forms was in 1888 and dealt with the catfishes, and by 1891 he had produced, "A Catalogue of the Fresh-water Fishes of South America" in collaboration with his wife. This work was intended to be a companion-piece to Jordan and Evermann's, "Fishes of North and Middle America," but circumstances prevented its completion in the form in which it was originally conceived.

Over the years he initiated several South American expeditions, some of which he accompanied and others which were managed by his colleagues. He worked over 20 years on preserved specimens before he was able to see the fish in their natural color. The early expeditions were financed by the Carnegie Museum at Pittsburgh, of which he was Curator of Ichthyology from 1909 to 1918. Indiana men who went on these trips were W. J. Moenkhaus, who will be mentioned later, John Nathan Pearson, now at Butler University, John Haseman, living at Linton, Indiana, and the late William Ray Allen who was head of the Zoology Department at the University of Kentucky. It is difficult to single out an individual piece of this phase of Eigenmann's work which was superior to the rest, but his name is probably most intimately associated with the characids and the catfishes.

Eigenmann's contributions to the local fish fauna began with, "A Catalogue of the Fishes of Bean Blossom Creek, Monroe County, Indiana" in 1886 with M. W. Fordice. This collection is famous because 40 species were found in a single mile of stream. "The Fishes of Indiana" by Eigenmann and C. H. Beeson was the most comprehensive of his work on the state's fauna. It appeared in the 1893 volume of these *Proceedings*.

Shortly before this time, he became attracted to the cave vertebrates, and he recognized that the cave environment was favorable to demonstrate evolutionary change. The caves of the United States and Cuba were combed for examples of blind vertebrates and 40 papers were written on the subject. The most active period of this research was done between 1898 and 1903. The studies of Eigenmann and his students were summarized in a synoptic paper, "The Cave Vertebrates of America, a Study of Degenerative Evolution" published in 1909 by the Carnegie Institution of Washington.

The opportunities offered by the cave fauna stimulated others to work in this field. Fernandus Payne should be mentioned especially in this connection. Payne performed experiments on the reactions of blindfish to light and determined that they obtained their food by the sense of touch. As one of the early directors of the Biological Station, Chairman of the Zoology Department, and Dean of the Graduate School, he fostered and preserved the interest in fishes and aquatic life at Indiana University. It was due to his efforts that the work was expanded in the 1940's in order to be of more service to the state.

The story of Eigenmann is intimately associated with the founding of the Indiana University Biological Station at Wawasee (Turkey) Lake in 1895, and its ultimate location at Winona Lake near Warsaw in 1899. Eigenmann's objective in founding the Station was to stimulate research on evolutionary problems. The lakes in northern Indiana were ideal for collecting material in large quantity for studies on variation. The most significant work on variation in fishes was done by W. J. Moenkhaus. He published two classical papers in this field between 1894 and 1898, using the logperch *(Percina caprodes)* and johnny darter *(Etheostoma nigrum)* as his material. Two of these papers can be found in volumes 11 and 13 of these *Proceedings*. He was among the first to attempt to distinguish different populations of the same species on a statistical basis. Moenkhaus also went on an expedition to South America where he collected fish for Eigenmann and spent a year as Assistant Director of the State Museum, São Paulo, Brazil. His other important work dealt with one of the first attempts at hybridization of fishes using two species of salt water cyprinodonts. Later he had a distinguished record as a physiologist in the Indiana University Medical School.

Eigenmann was not the only Jordan protegé working on fishes in Indiana during this period. Seth E. Meek received the Ph.D. degree at Indiana and later became Curator of Zoology at the Field Museum of Natural History in Chicago. While he was assistant curator, he compiled a "List of Fishes Known to Occur in the Waters of Indiana for the 1908 *Bienniel Report of the Commissioner of Fisheries and Game*. This was an illustrated popular article, but added no new information about the state's fauna. However, Meek and Samuel F. Hildebrand made a fine contribution to the ichthyology of northern Indiana in their 1910 paper, "A Synoptic List of the Fishes Known to Occur Within Fifty Miles of Chicago." This was based on an extensive series of collections and was the first publication on the fishes of northwestern Indiana. Hildebrand was a native Hoosier who received the A. B. degree at the Indiana State Normal School and made great contributions in systematic ichthyology in Central America. He became director of the U. S. Fisheries Laboratory at Beaufort, North Carolina, and was a distinguished ichthyologist with the Bureau of Fisheries for many years. Both Meek and Hildebrand became experts on the fishes of Central

America. One of their best pieces of work was a joint effort, on, "The Marine Fishes of Panama," published by the Field Museum.

Evermann and Howard Walton Clark were hard at work at Lake Maxinkuckee near Culver, Indiana. The aim of this project was to make a complete ecological study of a typical glacial lake, and most certainly this objective was accomplished. It now stands as one of the most complete ecological surveys ever conducted. It was only natural that the investigation should be done in Indiana since both Evermann and Clark were native sons. The work was begun under the sponsorship of the U. S. Fish Commission in 1899 and the last observations were made in 1908. The Commission lacked funds to publish the results, but finally in 1920 the Indiana Department of Conservation brought out "Lake Maxinkuckee, a Physical and Biological Survey." Many men collaborated in the survey. The list of people associated with the project reads like a "Who's Who" of American limnology. Among them was a plankton expert, Chauncey Juday, another son of Indiana who was a teacher in the Evansville schools at the time. His further history with Edward Birge, of Wisconsin, is one of the highlights in the development in limnology in the United States.

Willis S. Blatchley is best known as an entomologist, but he found the fishes too interesting to leave alone. One of his first major contacts with fishes was as a collector for Philip H. Kirsch who was sent to explore the Maumee and Eel River Basins of Indiana in 1892 by Evermann while he was an assistant to the U. S. Fish Commission. This work was very carefully done, and is the best reference material on northern Indiana prior to the contributions of the Biological Station. The results were published by Kirsch in the 1894 *Bulletin of the U. S. Fish Commission.*

Blatchley's position as state geologist from 1894 to 1911 gave him the privilege of compiling the annual reports, and they were filled with valuable natural history. The best of the fish papers was, "The Lakes of Northern Indiana and their Associated Marl Deposits," with G. H. Ashley in 1900. The paper contained lists of species from many lakes. In some cases the lists were copied from other publications without the courtesy of reference, but many represented original collections made by Blatchley himself. Blatchley worked on fishes off and on for many years, and in his later life he published a book, "The Fishes of Indiana" in 1938. Unfortunately the book contributed very little beyond what was known in the early 1900's.

The Later Years

Beginning in the 1920's work was begun by Will Scott, a student of Eigenmann's, which contributed directly to conservation problems. Scott was interested in all aspects of the aquatic community. He studied the morphometry and sedimentation of northern Indiana lakes, plankton, bottom fauna, and the food of fishes. Scott was responsible for the first cooperative arrangement between the Zoology Department and the Department of Conservation, a relationship which later became known as the Indiana Lake and Stream Survey. With small financial help it was possible to make surveys of the lakes and streams of northern Indiana as well as concentrated studies on problems of particular interest. The Biological Station, of which Scott was Director from 1924 to 1937, was used as a base of operations during this time.

From these studies emerged a series of publications titled, "Investigations of Indiana Lakes and Streams." The first issue appeared in 1928 and the journal has continued to the present. The wide variety of interests shared by Indiana aquatic biologists in these later years can be found in the 45 articles comprising the four volumes published to date. This is one of the first technical journals on aquatic life to be published by any state, and its inception was the direct result of Scott's initiative and vision.

Scott was an extraordinary teacher. He will long be remembered as a teacher of beginning zoology courses, and he was particularly effective in preparing graduate students for their careers. Ralph Hile did his doctorate research on the age and growth of several species by interpreting the marks on the scales at a time when this kind of work was just beginning in this country. This type of study has since become standard procedure in solving many practical and theoretical problems. Hile joined the U. S. Fish and Wildlife Service and was assigned to study the fishes of northern Wisconsin where he continued and expanded his life history work. His studies on the rock bass introduced several new techniques into the analysis of age and growth data, and information which he collected on the cisco made valuable contributions to the interpretation of subspeciation in the herrings. His later work has been on the analysis of populations of Great Lakes fishes with particular emphasis on fluctuations in abundance.

James Wilding performed experiments for his doctorate thesis on the oxygen threshold of three species, a subject which is important in defining the minimal respiratory requirements in unfavorable situations such as pollution. He also entered the U. S. Fish and Wildlife Service for a few years and is now engaged in radiological work at the Radiological Laboratory of the U. S. Air Force at Austin, Texas. Herman P. Wright analyzed the snail fauna of northern Indiana and determined the migration pathways of these animals into the area after the retreat of the Wisconsin glacier. Although not related to fishes directly, this reesearch was a fundamental contribution to the question of immediate post-glacial redistribution of animals. The pathways used by snails have been confirmed for the fishes, also. Wright died soon after completing his thesis.

Seven students studied for the Master's Degree with Scott. Two of them, John Black of Northeast Missouri State Teachers College, and James Leach of Ohio State University, continued their interest in fishes and subsequently received the doctorate at other institutions. Black collaborated with Carl L. Hubbs on several papers on the taxonomy of minnows, darters, and suckers. Leach has worked on the lamprey for many years, stressing their anatomy and physiology.

Following Scott's premature death in 1937, William E. Ricker came to the University in 1939 and took over the directorship of the Biological

Station and the Lake and Stream Survey. The Station had ceased to function as an undergraduate teaching unit at the end of the summer of 1937, but it became the summer headquarters of the Survey. Stronger ties with the Conservation Department and increased financial support allowed an expanded program, and in 1945 and 1946 Louis A. Krumholz and the writer joined the group. This association lasted until 1950 when Ricker left to become editor of the Fisheries Research Board of Canada and Krumholz joined the Oak Ridge National Laboratories.

Ricker obtained his doctorate at the University of Toronto and worked with the Pacific Salmon Commission and the Fisheries Research Board of Canada before coming to Indiana University. While with the Commission he was associated with the Cultus Lake investigations which are already famous for the thoroughness with which the salmon populations were charted as they moved to and from the lake. This experience stimulated an interest in the vital statistics of fish populations which he has followed ever since. "Further Notes on Fishing Mortality and Effort" in the 1944 volume of *Copeia* was the result of several years work on the general problem, and was followed in 1948 by a more general paper, "Methods of Estimating the Vital Statistics of Fish Populations," published in the *Indiana University Publications, Science Series.* These researches and others accelerated the work on population dynamics, and Ricker's place in this development was recognized in 1956 when he was invited to give the Baldi Lectures at the International Congress of Limnology in Finland.

The application of these fundamental researches has been widespread. In our own state this work created doubt about wisdom of seasonal regulations restricting the catch of panfish. As a result, seasonal restrictions were removed, and the move started a trend which has spread widely over the country. This is only one example of the practical applications associated with the work of the Lake and Stream Survey. The group worked closely with the Conservation Department and gave advice and information about many critical problems confronting the Division of Fish and Game.

Ricker's students include Wendell L. Johnson and John Gottschalk of the U. S. Fish and Wildlife Service in Washington, D. C., Donald C. Scott at the University of Georgia, Donald E. Wohlschlag at Stanford University, and the writer. All of these students have continued their interest in fishes and are now engaged in research or administration concerned with the production and utilization of fish populations.

David G. Frey came to Indiana University in 1950 and took over the responsibilties of Ricker. The Lake and Stream Survey continued actively until 1953 when the Department of Conservation withdrew its financial support. Funds from other sources have provided the means of continuing aquatic research in the state, but on a much more limited scale. Keith V. Slack recently completed a doctorate thesis which has a bearing on stream fish production, and several other graduate students are presently engaged in advanced degree problems.

There has been some research on fishes at other colleges and universities of the state. Hurst Shoemaker published a study on the distribution of fishes in Wayne County in 1942, while he was an instructor at Earlham College. Paul S. Stokely and Clarence E. Dineen at the University of Notre Dame have been working on the osteology and growth of fishes. Raymond M. Cable and his associates at Purdue University have studied the parasites of fishes for many years. The Department of Conservation now employs Harold McReynolds who is in charge of a project concerned with the fishes of the Muskatatuck River drainage in southeastern Indiana.

The Fish Collection

Jordan's fish collection was destroyed by fire in 1883 when lightning struck the Science Building at Indiana University. Jordan was in Europe at the time on one of the "Indiana Summer Tramps." As soon as he returned, he gathered the nucleus of a new collection around Woods Hole, Massachusetts, with the cooperation of the U. S. Fish Commission. The following winter he collected in Florida and Cuba, and the collection began to take shape once again. After this experience Jordan took precautions against another loss. He saved three series of species from his collections, and sent the first to the U. S. National Museum, the second to either Indiana or Stanford, and the third to a museum in Europe.

Eigenmann added an unusually rich collection of South American fishes to the collection, but after his death there was little interest in it. In order to place it where it would be used, the collection was sold to the California Academy of Sciences, and the money was used to acquire books and journals for the Biology Library. Lately, specimens of the North American freshwater species have been transferred from the California Academy to the Fish Division of the University of Michigan Museum of Zoology.

An extensive collection was made by the writer during work on the distribution of the state's fishes. For some time it was in storage due to lack of space, but a special room has been set aside for it in the newly constructed Jordan Hall of Biology which was occupied in 1955. The collection has now been arranged and is available for reference by interested persons.

A Comment

No bibliography of publications dealing with fishes by Indiana authors has been included. The task would be great indeed since Eigenmann alone had 225 titles to his credit and Jordan was very prolific during his years in Indiana. An almost complete bibliography on the taxonomy and distribution of Indiana fishes can be found in a paper written by the writer in 1945, "Distribution of the Fishes of Indiana," in the *Investigations of Indiana Lakes and Streams.*

Also, it has not been possible to include all the persons who have contributed to the rich literature on fishes stemming from Indiana. This sketch was intended to describe the main lines of work during the last 80 years and their omission is no reflection on the importance of their contributions.

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History of Water Conservation in Indiana

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Before the turn of the century, water conservation in Indiana was a rather nebulous thing. The many grist and saw mills utilizing the water power of our streams and the early canals constructed to provide water transportation, in a broad sense, might be classified as conservation practices even though their prime purpose was not to conserve water. When we consider that there were more than 2200 mills in Indiana in 1840, most of which impounded water and created small ponds and lakes, we must admit that those early pioneers did use our waters wisely, which is the essence of conservation.

Attempts were made, from time to time, in the early history of our state to collect information on the state's water resources and to prohibit certain practices that would adversely effect these resources. These efforts were the forerunner to water conservation as it is understood today. Before the conservation of water can be wisely practiced, it is essential to know something about the water that is available, and any study of these resources can rightly be classed as conservation.

The earliest measurements of stream flow in Indiana were made by Captain Howard Stansbury in 1835 and river stages were recorded as far back as 1883. It was not until 1902, however, that regular discharge measurements were started by the United States Geological Survey. The earliest reports on ground waters in the state were also made by the U. S. Geological Survey. In 1899, two reports, one on the wells of northern Indiana and another on the wells of southern Indiana, both by Frank Leverett were published by the Geological Survey. Another paper by Mr. Leverett on, "Water Resources of Indiana and Ohio" was published by that Survey in its 18th Annual Report. Stephen Capps, an employee of the Geological Survey, made a survey of the ground waters of 19 counties in north central Indiana in 1907, and the results of this study were published in 1910. The 1906 report of the Indiana State Board of Health, as well as others, contain considerable information on the public ground water supplies of the State. Other scattered references to the underground water conditions of Indiana occur in the various annual reports of the Indiana Department of Geology and Natural Resources and the Indiana Academy of Science. A general state-wide report on the ground waters of Indiana was compiled by Marshall Harrell and published by the Department of Conservation in 1935.

The first legal action taken to conserve water in the state was in 1905 when the State Legislature passed a law to preserve the fresh water lakes of the state and protect them from danger of being injuriously affected or destroyed by lowering the water. This law made it unlawful for anyone to construct a drainage ditch, having a bottom depth lower than the level of the lake, within forty rods of the lake, or to cut into or around any dam, bank or levee which might lower the waters of the lake. Prior to the completion of the dredging of the Kankakee River and the draining of the Grand Marsh in 1917, an unsuccessful effort was made by sportsmen and conservationists to prevent the loss of these thousands of acres of water.

It was not until 1919, when the law creating the Conservation Department was enacted, that water conservation, on a state wide basis, was given official recognition. This law states that the Department of Conservation shall have the power to investigate, compile and disseminate information and make recommendations concerning the natural resources of the state and their conservation including drainage, flood prevention, and development of water power, in addition to numerous other items. Two years later the Division of Engineering was created within the Department. Its chief duty, at that time, was to make surveys, investigate, compile and disseminate information and to make recommendations relative to the drainage and reclamation of lands so that conservation work could proceed more intelligently.

In 1922, one year after the Division of Engineering was established, a stream gauging program for the state was started with the establishment of 15 gauging stations. This project was carried on as one of the functions of the Division of Engineering until 1930 when an agreement was made with the Water Resources Branch of the U. S. Geological Survey to continue the work on a cooperative basis. This arrangement has continued to the present time. When the cooperative program was first started, the state's share of the program was mostly in the nature of services in lieu of cash, since no state funds had been specifically appropriated for a state-wide stream gauging program. However, in 1943 the legislature passed a law authorizing the Conservation Department to conduct a comprehensive study of the water resources of the State.

In 1935 the Division of Geology entered into an agreement with the U. S. Geological Survey to conduct a cooperative ground water investigational program in the state. Like the surface water program, this program was financed with services and whatever monies the Division could spare for that work until it was incorporated in the state study in 1943.

An examination of the annual reports for the Department from the time of its inception to the present reveal numerous activities in water conservation. As early as 1922 the Division of Engineering made a comprehensive investigation of drainage conditions of the Kankakee River Basin. A series of 165 shallow ground water wells were installed and water level data were collected for the years 1923 to 1927, inclusive. Problems relating to our natural lakes, such as the maintenance of normal water levels, relationship of lake levels to drainage of adjacent farm land, construction and operation of control dams and the protection of the natural features of the lake have been brought to the Department for solution throughout the years. The annual reports also make numerous references to the many investigations of drainage projects, problems related to ground water and surface water supplies, stream pollution abatement and other matters pertaining to the conservation of water.

In May, 1933, the Federal Civilian Conservation Corps started a program generally called the CCC program, and the Department under its authorization immediately established camps in many of its properties to carry out conservation projects. Similar camps were established under the Resettlement Administration program. Many water conservation projects were constructed during the existence of these programs, the major ones being large artificial lakes. Eighteen lakes, varying in size from a few acres to more than eight hundred acres, were built in state parks, game preserves and forests by conservation and resettlement camp employees. Under another made work program, the Department, through the Works Progress Administration or, W.P.A. constructed hundreds of small dams in the streams of the state and fifty or sixty large artificial lakes. Before these lakes were built, the land owner was required to sign an agreement with the State and Federal Government permitting public access and use of the lakes.

During the decade before the outbreak of World War II, the public's interest in water conservation became more and more evident. Before that time, the Department experienced little difficulty in keeping pace with the demands placed upon it for assistance in this field. However, with the passage of the Water Resources Act which provided funds for the state-wide water resources investigation, the passage of Chapter 279 authorizing the Department of Conservation to establish the water level of all the natural and artificial lakes within the state, and with the passage of Chapter 292 requiring the Department to review drainage projects affecting the level of the natural lakes, all of which were enacted in 1945, water conservation work was greatly expanded. Because of these new laws and with the demand for more specific information on ground water supplies, an increase in the number of requests for technical assistance on the construction of artificial ponds and lakes, and additional legislative proposals pertaining to the state's water resources, it was deemed necessary to create a new division within the Department to administer these programs. As a result, the Division of Water Resources was created in 1945.

In 1947 the Conservation Department sponsored a bill in the legislature to conserve the ground waters of the State. This bill was passed (Chapter 154 Acts 1947) and it marked the first attempt in Indiana to control any of the state's water resources by statute. Previously, common law prevailed in Indiana as far as the use of either surface or underground waters were concerned. This law made it unlawful for anyone to remove more than two hundred gallons of water per minute from the ground and use it for air conditioning or cooling purposes unless the water was returned to the ground, circulated through cooling devices and reused, or a permit obtained from the Department of Conservation to do otherwise. This law was repealed in 1951 and the present ground water control law, Chapter 29, which is much more comprehensive, was passed to replace it. Several other water conservation bills were sponsored by the Department in the 1947 legislative session and, two were enacted (Chapters 181 and 301). Under these it became unlawful for anyone to despoil the public fresh water lakes of the state by lowering their water level, filling in with soil or other substances or otherwise altering their beds and shore lines. A more comprehensive bill concerning the establishment of the water level of the lakes of the state was also passed in 1947. This law is Chapter 350. In 1951 the Department sponsored another piece of water conservation legislation which was enacted into law. Chapter 290 provides the necessary procedure by which property owners on a lake may raise the water level and construct a control structure for maintaining the established level.

In 1945 the General Assembly created the Flood Control and Water Resources Commission. It is charged with the responsibility of establishing a master plan for flood control of the State and to make plans and recommendations for the further development, protection and preservation of the water resources of Indiana. The Department and this Commission have worked closely together on water conservation measures.

During the past ten years water conservation has progressed more than in any period in the history of Indiana. According to the 1954 U. S. Agriculture Census there were more than 37,000 farm ponds in Indiana, most of which were built in the prior ten years. Cagles Mill Flood Control Reservoir, which has a conservation pool of 1400 acres, was completed in 1952. Ground breaking ceremonies were held on October 5 of this year for a similar reservoir on Raccoon Creek near Mansfield, which will have a conservation pool of approximately 1200 acres. The U. S. Engineers have approved three additional reservoirs on the Upper Wabash, two of which will have large conservation pools. The Indiana Flood Control and Water Resources Commission is studying several other sites for flood control reservoirs and is presently making a study of a multiple purpose reservoir on Salt Creek near Harrodsburg as authorized by the legislature in 1955. If this reservoir is constructed it will be the largest body of water in Indiana. The Conservation Department is presently buying land for a 1200-acre lake on Mud Creek at Glendale.

Under the cooperative program of the Department and the U. S. Geological Survey, considerable progress has been made in appraising the State's water resources although, because of limited funds, the work has not progressed as rapidly as would be desirable.

One of the most significant actions taken recently concerning the conservation of water was the passage in 1955 of the Indiana Water Resources Law. Under section one of this act, it states that the general welfare of the people of the State of Indiana requires that surface water resources of the State be put to beneficial uses to the fullest extent and that non-beneficial uses be prevented.

Increased attention is being focused on such water conservation measures as artificially recharging ground water aquifers, returning cooling water through diffusion wells, curtailing the flow from artesian wells, the replugging of old oil wells to prevent the loss and contamination of fresh ground waters, discouraging the use of potable ground water for the secondary recovery of oil, to say nothing of the soil conservation practices directed toward retarding run-off and holding as much rainfall as possible on the land where it falls.

The progress of water conservation in Indiana may have been somewhat slower since the turn of the century but from all indications, the progress in the future will be much faster because of the awareness of the public for the need of sound water conservation.

A Chronological History of the Soil Conservation Service and Related Events

R. O. COLE, Purdue University

A great impetus was given to the conservation movement in this country when the Federal Soil Conservation Service was created in 1935. Prior to this time an action program had been started and prior to that the first erosion experiment stations were established. These experiment stations were established in 1929 and the action programs were started in 1930. Many people feel that this marks the beginning of the conservation program in this country. Those holding to this belief are correct inasmuch as the federally sponsored programs are concerned. In fact, it was not until the early 1930's that conservation of natural resources began to receive national and international attention.

If we look farther back into history we find that a number of our forefathers were conservationists in the strictest sense of the word. George Washington, Thomas Jefferson and many others not only believed in conservation but practiced it on their holdings. Jefferson is given credit for saying, "He is the greatest patriot who stops the most gullies." George Washington is given credit for being the father of his country by everyone. By many he is credited with being the father of conservation also. Washington practiced conservation at Mount Vernon and spoke and wrote with authority on the subject. During this period of the beginning of our national life the number of conservationists was small as compared with the present time. Those who practiced and spoke out for conservation of natural resources were decidedly in the minority. Many of our forefathers felt a greater urge to plow up the grasslands and clear the forests than to conserve these resources.

If we should look farther back into ancient history, the records reveal evidences of conservation but at the same time much evidence of soil destruction. The ruins of Greece, China and other older civilizations are mute reminders of man's failure to conserve soil and water. The Bible gives certain references to God's admonition to both use and conserve. Many feel that the instruction to rest 1/7th of the time was meant to apply to the land as well as to the people.

Considerable favorable reaction to the need for a national conservation program came out of President Theodore Roosevelt's Conservation Conference which was held in 1907. Here the governors of the states went on record endorsing the need for a national conservation program.

In Indiana, especially within the southern part of the state, some attention was given to the application of the conservation practices prior to 1920. The principal practice recommended and used was terracing. Demonstrations of terrace construction were held by a few county agents assisted by the Agricultural Engineering Department of

Purdue University. In 1919 the late Prof. M. L. Fisher published the Purdue Experiment Station Circular No. 90 entitled "Washing Lands of Indiana—A Preliminary Study." In this publication, Professor Fisher emphasized the seriousness of water erosion in Southern Indiana and enumerated several corrective measures. This circular was profusely illustrated with photographs of eroded areas. In fact, the cuts were numerous and showed the most serious conditions. Professor Fisher recommended terracing, strip cropping, a greater use of cover, pasture improvement and many of the practices which we use and recommend today.

It is the purpose of this paper, however, to relate the developments in the creation and functioning of the Federal Soil Conservation Service from its beginning as the Soil Erosion Service to the present. The Soil Erosion Service was established as a temporary organization in the U. S. Department of Interior without formal order. A resolution was passed by a special Board of Public Works and an allotment of five million dollars was made to the Department of Interior for soil erosion prevention work on public and privately owned lands on July 17, 1933.

Recognition of the menace of soil erosion to the nation's agriculture was recognized when in 1929 the Buchanan Amendment to the Agricultural Appropriation Bill for the fiscal year 1930 was adopted. This amount provided $160,000 to be used by the Secretary of Agriculture for soil erosion investigations. This same year soil erosion experiment stations were set up under the Bureau of Chemistry and Soils in cooperation with the Bureau of Agricultural Engineering. A portion of the funds were assigned to the Forest Service to supplement what this service was doing in the study of the influence of forest cover on runoff. These appropriations were continued to the Department of Agriculture after the transfer of the Soil Erosion Service from the Department of Interior was made.

On September 19, 1933, the actual operation of the Soil Erosion Service began. Dr. Hugh H. Bennett was transferred from the Department of Agriculture to the Department of Interior to act as director of the new agency. Dr. Bennett was the only employee of this Service on that date. On the following day, Lillian Wieland entered on duty as Dr. Bennett's secretary. From this beginning the Service grew rapidly and many employees were added during the next several years. On October 8, 1933, Dr. Bennett prescribed the organization of the Soil Erosion Service and stated its functions and plan of operation. The first soil erosion control project was established on October 10 on the Coon Creek Project in Coon Valley, Wisconsin with headquarters at LaCrosse, Wisconsin. A few days later, Dr. Walter C. Lowdermilk entered the Service as its vice director.

By April 1, 1934, 22 Emergency Conservation Work Camps were assigned to and began operation under the technical direction of the Soil Erosion Service. Some Civil Works Administration and ECW labor had been utilized by other agencies prior to this time.

May 11, 1934 is a historic event in conservation annals. It was on this date that a great catastrophe occurred in the region of the

Great Plains which resulted in focusing nationwide attention on the need for more conservation effort. The catastrophe referred to was the great dust bowl which started with the nation's first great dust storm. This storm blew fine soil particles from the Great Plains to Washington, D. C., and as much as 300 miles out into the Atlantic Ocean.

In order to secure more information concerning the menace of soil erosion nationally and to provide maps which could be used immediately, a nation-wide reconnaissance survey was begun on August 15, 1934. This survey was completed in two months. On March 6, 1935, the second great dust storm occurred. Again great clouds of topsoil from the fields of Kansas, Colorado, Texas and Oklahoma swept over Washington and the states of the eastern seaboard and out to sea.

Soon after this it became apparent that the Soil Erosion Service more properly belonged in the Department of Agriculture. By order of the Federal Emergency Administrator of Public Works, on March 23, 1935 the Soil Erosion Service was transferred from the Department of Interior to the Department of Agriculture. This transfer was approved by the president on March 25. The transfer included all funds, personnel and property. At this time there were in operation 39 erosion control projects and 51 Emergency Conservation Work Erosion Camps. Those ECW camps assigned to the Forest Service for the purpose of doing forestry erosion work on public lands were transferred from the Forest Service to the Soil Erosion Service. Additional camps were also added.

The Secretary of Agriculture in the spring of 1935 realized the need for greater unification of activities pertaining to the control of soil erosion within the department and issued a memorandum by which this was partially brought about. This memorandum set out the fact that the Soil Erosion Service would operate as a separate unit of the department but that it would also include the soil erosion investigational work and the service and control work of the department. The ten experiment stations which were transferred in this memorandum were located at Guthrie, Oklahoma; Temple, Texas; Hays, Kansas; Tyler, Texas; Bethany, Missouri; Statesville, North Carolina; Pullman, Washington; Clarinda, Iowa; LaCrosse, Wisconsin and Zanesville, Ohio. A number of erosion control nurseries were also transferred in this order.

On April 27, 1935, Public 46 of the 74th Congress, creating the Soil Conservation Service was passed. This act directed the Secretary of Agriculture to establish an agency to be known as the Soil Conservation Service. On this same day, the Secretary issued a departmental memorandum establishing the Service within the Department of Agriculture and providing that this new agency include the activities conducted under the Soil Erosion Service. It further designated Dr. H. H. Bennett, Chief of the Soil Conservation Service and W. C. Lowdermilk, Associate Chief. From September through December, regional offices were established in each of 11 regions. A regional conservator was placed in charge of each regional office. On December 27, 10,325 employees of the Soil Conservation Service acquired classified civil service status. By the end of 1935, the Service was operating 498 ECW camps, otherwise referred to as CCC Camps.

In the summer of 1935 the first Demonstrational Project in Indiana was established. It was known as Leatherwood Creek Watershed Project in Lawrence County. The Project offices were located in Bedford. On this area, all of which drained into Leatherwood Creek, farms were planned for conservation and numerous conservation practices were established on them. These practices included terracing, contour farming, strip cropping, woodland and pasture management, tree planting and many others.

WPA labor was furnished to set trees, move fences and build erosion control structures. Lime, seed, trees, fencing and other materials were furnished to encourage farmers to cooperate in the program.

In the next three years, two similar projects were established. One was in Henry County and the other in Benton County. The number of ECW camps in the State during this period varied from 10 to 14.

On February 29, 1936, Public 461 of the 74th Congress, known as the Soil Conservation and Domestic Allotment Act, was enacted. This placed in operation the payments of grants-in-aid to farmers for carrying out soil conserving and soil building practices. It amended the August 24, 1935 act which was designated as the Agricultural Adjustment Act. By June, the Flood Control Act was passed which gave certain responsibilities to both the Secretary of War and of Agriculture in the carrying on of a national program of flood control.

In September 1936, the peak employment of WPA labor utilized by SCS was reached.

Up to the end of 1936 no provision had been made for local participation in the administration of federal conservation activities. Programs of conservation planning and the application of conservation practices were being offered to and accepted by farmers throughout the nation by both ECW camps and demonstrational projects. In Indiana, there were in addition to the ten camps administered by the SCS, a number administered by the Park Service, the Forest Service and the Bureau of Agricultural Engineering. It had become increasingly evident that there should be more local participation in the conservation program to make it more appealing and enduring. Farmers were inclined to accept a complete conservation program for their farm and to agree to carry it out only because they wanted to receive certain work or materials for the establishment of practices in which they were especially interested. After such assistance had been rendered, in all too many cases, they failed to carry out the complete program as developed for them. It was unfortunate, too, that many of these programs were developed for the farmer rather than in cooperation with him. Such weaknesses caused the leader to begin planning for formation of local organizations which would be responsible for directing the conservation program.

On February 27, 1937, the president addressed a letter to the governor of each state urging him to support the passage of state legislation to effectuate the formation of soil conservation districts. With this letter, a standard soil conservation districts law was included.

This standard act was prepared by the Department of Agriculture but at the suggestions of representatives from many of the states. On March 3, the first soil conservation districts law was enacted in Arkansas and approved by its governor. In the legislature of this same year, Indiana's Enabling Act was passed. Our state was one of the first four states to enact this law.

On August 4 of this same year, the Brown Creek Soil Conservation District, the first to be organized in the U. S. was organized in Anson and Union Counties, North Carolina. On the 16th day of January, 1940, a referendum creating the first district in Indiana comprising a part of Vanderburgh County was held. A Certificate of Organization was issued to the Southwestern Indiana District on the 15th of February of the same year. Soon thereafter, the first county-wide district was formed in Knox County, the referendum having been held on the 5th of February and the Certificate of Organization being issued to the Knox County District on April 4. The organization of districts has proceeded from this beginning to the point that there are at the present time, 69 districts covering essentially that many counties of the state organized into districts. District organization is progressing at the present time in 5 other counties. By April 24, 1941, Alabama became the first state to have all of its farm land included within soil conservation districts.

On May 22, 1941 the first CPS Camp, Civilian Public Service Camp, was assigned to the Soil Conservation Service for use. A total of 15 such camps assisted with the program being carried on by the service. This was a part of the program of employing conscientious objectors on work of national importance in lieu of military service. Food, medical care and welfare were provided without cost to the government.

By the beginning of fiscal 1942, the Service was reorganized. In this reorganization, 3 regional offices were abolished. In April 1943 the Service became a part of the War Food Administration. The last of the demonstration projects were closed by June 30, 1944. In 1951 SCS was given responsibility for the technical phases of the permanent type of conservation work done by the Production and Marketing Administration. Dr. Bennett reached retirement age April 15, 1951. His period of service was extended to April 30, 1952 by presidential order.

All regional offices were abolished in 1953. Most of their responsibilities were given to the state offices of the Service. Earlier in this year, the Service was assigned the responsibility of approving areas to serve as pilot watersheds. On such areas, 50 or more of which were established, studies were made of the combined soil conservation and flood control work on small watersheds. One was established in Pike and Dubois Counties, Indiana. These pilot watersheds, serviced and administered by the Soil Conservation Service, were designed to find the best ways and means of flood control and conservation using the entire watershed as a laboratory.

Small watersheds as we have them today are set up under Public Law 566. Several of these projects are in process of being organized within the state at this time. They are sponsored by local soil conservation districts. State approval is given by the Flood Control and

Water Resources Board and federal approval by the Department of Agriculture. In these projects the expense of flood control work is borne by the federal government while the conservation practices are establishd by the land owners within the watershed. Technical assistance is provided by the Soil Conservation Service. Public Law 566 repealed the Department of Agriculture's authority for flood prevention measures under the Flood Control Act of 1936 except for the programs authorized on 11 major watersheds. None of these watersheds are located within Indiana.

At the present time it may be said that the Soil Conservation Service divides its activities in four ways. Its first responsibility is to furnish technical assistance to legally organized soil conservation districts. More than 2,600 of such organizations have been formed in every state and territory of the nation. Farmers within these legally constituted governmental divisions of state or territory are funished technical planning and application assistance to establish conservation plans on their lands. A similar type of assistance is furnished within small watersheds which are sponsored in the beginning by the districts and later by watershed organizations. The Service here goes beyond that offered within the districts since materials, structures, etc., for flood control are furnished over and above the application of practices on the lands within the watershed area. Another part of the Service's activity is providing technical assistance to farmers participating in the agricultural conservation program of the ASC. Farmers thus participating receive grants-in-aid as cost sharing. Determination of the need for the practices on which cost sharing is to be paid and the approval of these practices is a responsibility of the Soil Conservation Service. Other responsibilities of the Service are directing the National Soil Survey Program and the Conservation Needs Inventory.

Donald A. Williams is the present administrator of the Soil Conservation Service. He was preceded by the late Robert M. Salter who served as chief from November 13, 1951 to November 1, 1953. Dr. H. H. Bennett was chief from April 27, 1935 to November 12, 1951.

As of June 30, 1955, the Service employed 14,973 persons, 12,492 of which were on competitive employment. At this time there are 2,654 soil conservation districts and 20 other districts being assisted. These contain an approximate land area of 1,484,974,000 acres. The Service is now more than 21 years old. It is of legal age and an established agency in the Department of Agriculture.

PHYSICS

Chairman: ALLAN MITCHELL, Indiana University

MALCOLM CORRELL, DePauw University, was elected chairman for 1957

ABSTRACTS

Determination of Masses from Disintegration Energies as Measured by Beta- and Gamma-Ray Spectra. ALLAN C. G. MITCHELL, Indiana University.—Mass differences can be measured very accurately by means of total disintegration energies determined from beta- and gamma-ray spectra. In general, mass differences can be determined by this means with an accuracy of a few kilovolts while reaction energies and mass spectrometer differences can only be given with errors of the order of tens of kilovolts. Various coincidence techniques are discussed which are helpful in determining the total disintegration energy and examples are given. Mass differences of stable isobars, determined with the help of radioactive species which undergo both beta-ray and positron emission, are compared with similar results obtained by mass spectroscopic means. Some corrections to the table of total disintegration energies are given.

Some Novel Orientations of Dipole Fields. MALCOLM CORRELL, DePauw University.—Two dimensional illustrations of dipole fields usually have the dipole axis parallel to the plane of projection. Projected field line configurations are to be shown for cases where the dipole axis is not parallel to the plane of projection.

Magnetic Fields Suggested by Solar Prominence Streaming. MALCOLM CORRELL, DePauw University.—Solar Prominences are frequently characterized by streaming motions along paths which suggests magnetic field configurations. Several attempts to fit idealized field patterns to such streamers are to be reported.

Comparison of a Vacuum Trajectory with an Actual Trajectory. EARL MARTIN, Hanover College.—Using the theoretical equations for the motion of a particle in a uniform field of force its path is determined. From the results of a great many firings of large guns of various calibers tables have been set up and empirical equations found which express the values given in the tables. A curve is plotted from these equations which shows the actual path of the projectile.

Scattering of 19-Mev Alpha Particles by Ne, Al, A, and Cu.[1] E. BLEULER, O. GAILAR, L. SEIDLITZ, and D. J. TENDAM, Purdue University.—The elastic and inelastic scattering of 19-Mev alpha particles by Ne, Al, A, and Cu were measured from 12° to 170°. Photographic plates, spaced every 2.5°, were used for the gases, a rotating counter telescope for the metals. The r.m.s. deviations of the scattering angles from the mean values were of the order of 0.3°. The scattering patterns from the ground state and the first excited state of Ne show nearly equidistant minima and maxima. Assuming a square-well nuclear potential and using the Born approximation one obtains interaction radii of 6.4 and 6.7×10^{-13} cm, respectively. The angular distributions from the second, third, and fourth level are irregular and don't permit a simple interpretation. The scattering patterns from A are similar and correspond to a radius of 6.9×10^{-13} cm. From the elastic scattering by Al a radius of 6.4×10^{-13} cm is calculated, whereas at 40 Mev a value of 5.4×10^{-13} Mev has been found. The difference probably indicates a failure of the Born approximation; accurate calculations, with a view to determine the optical-model parameters for the alpha-nucleus interaction, are in progress elsewhere. No simple analysis has been tried yet for the elastic scattering by Cu and the inelastic-scattering patterns from Al and Cu which show large but irregular fluctuations.

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[1] Supported in part by the U. S. Atomic Energy Commission.

The Integral Equations for the Transition Matrices in the Static Meson Theory.[1] NOBUYUKI FUKUDA and JULIUS KOVACS, Indiana University.—The Chew-Low-Wick integral equation for the scattering matrix in the static meson theory has been generalized so as to make it possible to treat the various pion processes in which arbitrary numbers of pions are involved. Such a generalization is also necessitated if one wants to take into account the contribution of two or more meson configurations in pion-nucleon scattering. The outgoing or incoming wave functions corresponding to the many-meson initial states are defined in the same manner as by the above-mentioned authors in the one-meson problem, and are shown to be identical with those introduced by Lippmann and Schwinger. An approximate expression for the two-meson production matrix is obtained and some correction terms due to this production are derived for Chew Low one-meson equation.

The Beta Decay of Tb^{161}. W. G. SMITH, J. H. HAMILTON, R. L. ROBINSON, and L. M. LANGER, Indiana University.[1]—The radiations emitted in the beta decay of 7 day Tb^{161} have been studied with a 180°, 40 cm. radius of curvature, shaped magnetic field spectrometer and a scintillation counter. Gamma-gamma coincidence measurements have also been made. The following transitions with multipolarities indicated were observed (energy in kev): 25.5(EL), 48.9(Ml), 56.9(El, tentative), and 74.6(El). The following beta groups were also observed (energy in kev): 571, 522, 496, and 439. A level scheme incorporating these data is presented.

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[1] Supported by the National Science Foundation and the Joint Program of the ONR and the A.E.C.

[1] Support by the joint program of the U. S. Office of Naval Research and the U. S. Atomic Energy Commission, and by a grant from the Research Corporation.

Intersecting Beam Accelerator With Storage Ring.[1] D. B. LICHTENBERG, R. G. NEWTON and M. H. ROSS, Indiana University.—Much higher energies are available for the study of nuclear phenomena if two beams of particles traveling in opposite directions are made to intersect rather than letting one beam strike a stationary target. Instead of building two separate accelerators to shoot particles at each other, it may be preferable to inject the beam from a single accelerator into a storage ring. The beam would then circulate in the storage ring at high energy until another beam was accelerated, at which time the two beams would collide. The principal difficulty is that of achieving high intensity beams so that there will be a sufficient number of collisions to be able to do accurate experiments. Liouville's theorem sets a limit on the intensity that can be achieved and leads to the requirement that the particles be transferred from the accelerator to the storage ring with high efficiency. A magnetic device known as the regenerative deflector shows promise of being able to accomplish this.

Forces Between Strange Particles and Nucleons.[1] MARC ROSS and D. B. LICHTENBERG, Indiana University.—It is found experimentally that the heavy strange particles—hyperons—interact strongly with nucleons. A model has been adopted which assumes that Π-mesons are responsible for this strong interaction. In addition, it is assumed that the spin of the hyperons is ½, the same as the spin of the nucleons, and that the Σ and Λ hyperons have the same parity. With these assumptions and several mathematical approximations, the forces between hyperons and nucleons have been calculated. There is one free parameter in the calculation which is fixed by comparison with experiment. The calculation predicts that the forces between the Λ hyperon and nucleon are highly spin dependent and that the forces between the Σ^+ hyperon and proton are relatively weak compared to the Λ-proton forces.

On Ghost States in Field Theory.[1] ROGER G. NEWTON, Indiana University.—Since the discovery by Källen and Pauli that the simple model field theory of T. D. Lee for the interaction of three kinds of particles contains physically undesirable bound states whose occupation probability is negative, real field theories such as quantum electrodynamics have been suspected of the same fault. The evidence, although inconclusive, seems to show that electrodynamics has indeed similar properties. We are investigating the question from the point of view of the conventional expansion in powers of the fine structure constant. It then appears that even in the lowest approximation several different electron masses occur, not all of which have real positive probability.

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[1] Supported by the NSF.

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PLANT TAXONOMY

Chairman: CARROLLE A. MARKLE, Earlham College

JOHN E. PELTON, Butler University, was elected chairman for 1957

ABSTRACTS

Variation in *Helianthus angustifolius*. WILLIAM C. MARTIN, JR., Indiana University.—Variation of 8 characters in *H. angustifolius* was studied from over 500 herbarium specimens from all parts of its range. Examination of microsporocytes revealed the species to be diploid with $n=17$ chromosomes. The species was found to be highly variable morphologically, but no clinal trends were evident. Probably both environmental modification and hybridization with other species accounts for the local variation encountered. Habitat differences appear to profoundly modify the species in many areas, particularly in New York and New Jersey. Hybridization with *H. salicifolius* probably explains some of the variants encountered in Texas, Oklahoma and Arkansas. A putative hybrid with *H. atrorubens* is described from North Carolina. The possibility of hybridization with *H. floridanus* and *H. occidentalis* is also discussed.

A Rare Dinoflagellate New to Indiana. WILLIAM A. DAILY, Butler University.—*Peridinium Volzii* f. *vancouverense* (Wailes) Lefevre, a dinoflagellate, heretofore has been reported from only British Columbia, Australia and Minnesota. Indiana is now added to this list. (To be published in the Butler Univ. Bot. Stud. XIII, 1956.)

A Study of Evidences of Introgression Among *Viburnum lentago, V. prunifolium,* and *V. rufidulum* Based on Leaf Characteristics. JOE H. BRUMBAUGH and A. T. GUARD, Wabash College and Purdue University.—The range of *Viburnum lentago* L. is northernmost and that of *V. rufidulum* Raf. is southernmost. Little overlapping of ranges occurs between these two species. *V. prunifolium* L. occurs between *V. lentago* and *V. rufidulum* and often overlaps the ranges of these two species. Each species appears to be best suited to a particular type of habitat: *V. lentago* occupies poorly drained areas; *V. prunifolium,* moist borders of woods; and *V. rufidulum,* dry rocky slopes. The above conditions provide favorable situations in which hybridization and resulting introgression could be occurring. The authors conclude that hybridization and introgression could be occurring and that introgression may be an important factor in presenting taxonomic difficulty in accurately defining the species.

Contributions to the Flora of Wayne County, Indiana, II

CARROLLE A. MARKLE,[1] Earlham College

A study of the herbaceous dicotyledonous plants of Wayne County, Indiana, was made during the academic year 1955-1956. All specimens collected in Wayne County and now a part of the Earlham College Herbarium, housed and maintained by the Biology Department, were placed in specially marked, separate folders and these folders placed in the herbarium directly after the out-of-county folders in each family. Hence the county sheets can be "pulled" for study, readily, at any time.

A card was then typed for each genus known to be represented in Indiana and under the genus were listed all species previously reported for Wayne County in Deam's Flora of Indiana. If one of these species was found to be represented in the Earlham College Herbarium it was so indicated on the card. If a species was reported for counties adjacent to Wayne County, but not for the county itself this was also indicated on the cards and the herbarium was checked for specimens. From this card index of checked species a list of those of the county was then compiled. No species were included in the list unless previously reported by Deam or now present in the Earlham College Herbarium, hence the list is not to be considered complete, even for the genera reported. It should be noted that the *Compositae* are not included in this report, but it is hoped that a further study, including the monocotyledonous species and species of composites will follow.

The following list includes 341 species, 154 of which were not included in Deam's Flora of Indiana. They belong to 200 genera and 57 families. The sequence of genera and the nomenclature is in accord with that used in Gray's Manual of Botany, 8th Edition, but species are given alphabetically within the genera.

A List of the Dicotyledonous Herbaceous Species of Wayne County, Indiana.

(Exclusive of Species of the Family *Compositae*)

Cannabinaceae: *Cannabis sativa* L. Urticaceae: *Laportea canadensis* (L.) Wedd., *Pilea pumila* (L.) Gray, *Boehmeria cylindrica* (L.) Sw. *Parietaria pensylvanica* Muhl. Santalaceae: *Comandra umbellata* (L.)

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[1] The author wishes to acknowledge the financial assistance afforded by a grant received from the Research Grants Committee of the Indiana Academy of Science. She also wishes to express her appreciation for the organizational work done with the herbarium material by two Earlham seniors, Patricia Boring and Edward Beals. The careful checking and preparation of the final list was done by Mrs. Lois Joyner, Earlham '55, without whose able assistance the project could not have been completed at this time.

Nutt. Aristolochiaceae: *Asarum canadense* L., *A. canadense* var. *acuminatum* Ashe, *A. canadense* var. *reflexum* (Bickn.) Robins., *Aristolochia Serpentaria* L. Polygonaceae: *Rumex Acetosella* L., R. *crispus* L., *R. obtusifolius* L., *R. orbiculatus* Gray, *Tovara virginiana* (L.) Raf., *Polygonum cristatum* Engelm. and Gray, *P. Persicaria* L., *P. punctatum* Ell., *P. sagittatum* L. Chenopodiaceae: *Cycloloma atriplicifolia* (Spreng.) Coult., *Chenopodium album* L., *C. ambrosioides* L., *C. murale* L. Amarantaceae: *Amaranthus graecizans* L., *A. hybridus* L., *A. retroflexus* L., *Froelichia gracilis* (Hook) Moq. Phytolaccaceae: *Phytolacca americana* L. Aizoaceae: *Mollugo verticillata* L. Portulacaceae: *Portulaca oleracea* L., *Claytonia virginica* L. Caryophyllaceae: *Paronychia canadensis* (L.) Wood, *P. fastigiata* Raf., *Arenaria lateriflora* L., *A. serpyllifolia* L., *Stellaria longifolia* Muhl., *S. media* (L.) Cyrille, *S. pubera* Michx., *S. pubera* var. *silvatica* (Beguinot) Weath., *Cerastium nutans* Raf., *C. vulgatum* L., *C. vulgatum* forma *glandulosum* (Boenn.) Druce, *Agrostemma Githago* L., *Silene antirrhina* L., *S. noctiflora* L., *S. stellata* (L.) Ait., *S. virginica* L., *Saponaria officinalis* L. Ranunculaceae: *Ranunculus abortivus* L., *R. hispidus* Michx., *R. recurvatus* Poir., *R. sceleratus* L., *R. septentrionalis* Poir., *R. septentrionalis* var. *cancetorum* (Greene) Fern., *Thalictrum dasycarpum* Fisch. & Lall., *T. dioicum* L., *T. revolutum* DC., *Anemonella thalictroides* (L.) Spach., *Hepatica acutiloba* DC., *Anemone quinquefolia* L. var. *interior* Fern., *A. virginiana* L., *Clematis virginicum* L., *Capsella Bursapastoris* (L.) Medic., *Brassica nigra* (L.) *Aquilegia canadensis* L., *Delphinium tricorne* Michx., *Cimicifuga racemosa* (L.) Nutt., *Actaea pachypoda* Ell., A. *rubra* (Ait.) Willd., *Hydrastis canadensis* L.

Berberidaceae: *Podophyllum peltatum* L., *Jeffersonia diphylla* (L.) Pers., *Caulophyllum thalictroides* (L.) Michx. Papaveraceae: *Sanguinaria canadensis* L., *Stylophorum diphyllum* (Michx.) Nutt., *Chelidonium majus* L., *Dicentra canadensis* (Goldie) Walp., *D. cucullaria* (L.) Bernh., *Corydalis flavula* (Raf.) DC., *Fumaria officinalis* L. Capparidaceae: *Polanisia graveolens* Raf. Cruciferae: *Draba verna* L., *Alyssum Alyssoides* L., *Thlaspi arvense* L., *Lepidium campestre* (L.) R. Br., *L. virignicum* L., *Capsella Bursapastoris* (L.) Medic., *Brassica nigra* (L.) Koch, *B. Rapa* L., *Hesperis matronalis* L., *Erysimum cheiranthoides* L., *Rorippa islandica* (Oeder) Borbás, *Nasturtium officinale* R. Br., *Barbarea verna* (Mill.) Aschers., *B. vulgaris* R. Br., *Iodanthus pinnatifidus* (Michx.) Steud., *Dentaria laciniata* Muhl., *Cardamine bulbosa* (Schreb.) BSP., *C. Douglassii* (Torr.) Britt., *C. pensylvanica* Muhl., *Arabis laevigata* (Muhl.) Poir., *A. patens* Sulliv.

Crassulaceae: *Sedum telephioides* Michx., *S. ternatum* Michx. Saxifragaceae: *Penthorum sedoides* L., *Mitella diphylla* L., *Parnassia glauca* Raf. Rosaceae: *Fragaria virginiana* Duchesne, *F. virginiana* var. *illinoensis* (Prince) Gray, *Waldsteinia fragarioides* (Michx.) Tratt., *Potentilla norvegica* L., *P. recta* L., *P. simplex* Michx., *Filipendula rubra* (Hill) Robins., *Geum canadense* Jacq., *G. laciniatum* Murr. var. *trichocarpum* Fern., *G. vernum* (Raf.) T. & G., *G. virginianum* L., *Agrimonia gryposepala* Wallr., *A. rostellata* Wallr.

Leguminosae: *Cassia hebecarpa* Fern., *Trifolium hybridum* L., *T. praetense* L., *T. procumbens* L., *T. repens* L., *Melilotus alba* Desr., *M. officinale* (L.) Lam., *Medicago sativa* L., *Desmodium canadense* (L.) DC., *D. canescens* (L.) DC., *D. glutinosum* (Muhl.) Wood., *D. nudiflorum* (L.) DC., *D. paniculatum* (L.) DC., *Vicia villosa* Roth., *Apios americana* Medic., *Phaseolus polystachios* (L.) BSP., *Amphicarpa bracteata* (L.) Fern. var. *comosa* Fern.

Oxalidaceae: *Oxalis europaea* Jord. forma *cymosa* (Small) Wieg., *O. europaea* forma *villicaulis* Wieg., *O. stricta* L., *O. violacea* L. *Geranium carolinianum* L. var. *confertiflorum* Fern., *G. dissectum* L., *G. maculatum* L. Polygalaceae: *Polygala Senega.* L. Euphorbiaceae: *Croton monanthogynus* Michx., *Acalypha rhomboidea* Raf., *A. virginica* L., *Euphorbia corollata* L., *E. Cyparissias* L., *E. dentata* Michx., *E. maculata* L., *E. Peplus* L. Limnanthaceae: *Floerkea proserpinacoides* Willd. Balsaminaceae: *Impatiens capensis* Meerb., *I. pallida* Nutt. Malvaceae: *Malva neglecta* Wallr., *M. rotundifolia* L., *Sida spinosa* L., *Abutilon Theophrasti* Medic., *Hibiscus Trionum* L. Guttiferae: *Hypericum mutilum* L., *H. perforatum* L., *H. punctatum* Lam. Violaceae: *Hybanthus concolor* (T.F.Forst) Spreng., *Viola missouriensis* Greene, *V. papilionacea* Pursh, *V. pensylvanica* Michx., *V. rostrata* Pursh, *V. sororia* Willd., *V. striata* Ait., *V. triloba* Schwein.

Passifloraceae: *Passiflora lutea* L. var. *glabriflora* Fern. Lythraceae: *Cuphea petiolata* (L.) Koehne. Onagraceae: *Lugwigia palustris* (L.) Ell. var. *americana* (DC.) Fern & Grisc. *Epilobium coloratum* Biehler, *E. strictum* Muhl., *Oenothera biennis* L. var. *hirsutissima* Gray, *O. biennis* var. *pycnocarpa* (Atkinson & Bartlett) Wieg., *Gaura biennis* L., *Circaea quadrisulcata* (Maxim.) Franch. & Sav. Araliaceae: *Aralia racemosa* L., *Panax quinquefolius* L. Umbelliferae: *Sanicula canadensis* L., *S. gregaria* Bickn., *S. marilandica* L., *S. trifoliata* Bickn., *Chaerophyllum procumbens* (L.) Crantz., *Osmorhiza Clayton* (Michx.); C. B. Clarke, *O. longistylis* (Torr.) DC., *Erigenia bulbosa* (Michx.) Nutt., *Conium maculatum* L., *Zizia aptera* (Gray) Fern., *Z. aurea* (L.) W.D. J.Koch, *Cicuta maculata* L., *Cryptotaenia canadensis* (L.) DC., *Sium suave* Walt., *Thaspium barbinode* (Michx.) Nutt., *T. trifoliatum* (L.) Gray var. *flavum* Blake, *Angelica atropurpurea* L., *Oxypolis rigidior* (L.) C. & R., *Pastinaca sativa* L., *Heracleum maximum* Bartr., *Daucus Carota* L.

Pyrolaceae: *Monotropa uniflora* L. Primulaceae: *Dodecatheon Meadia* L., *Lysimachia ciliata* L., *L. hybrida* Michx., *L. Nummularia* L., *Anagallis arvensis* L., *Samolus parviflorus* Raf. Gentianaceae: *Gentiana Andrewsii* Griseb., *G. crinita* Froel., *G. procera* Holm, *G. quinquefolia* L. var. *occidentalis* (Gray) Hitchc., *Swertia caroliniensis* (Walt.) Ktze. Apocynaceae: *Apocynum cannabinum* L., *A. cannabinum* var. *pubescens* (Mitchell) A. DC. Asclepiadaceae: *Asclepias incarnata* L., *A. syriaca* L., *A. tuberosa* L., *Ampelamus albidus* (Nutt.) Britt. Convolvulaceae: *Ipomoea pandurata* (L.) G.F.W.Mey., *I. purpurea* (L.) Roth., *Convolvulus arvensis* L., *C. sepium* L., *Cuscuta campestris* Yuncker, *C. Cephalanthi* Engelm., *C. Gronovii* Willd.

Polemoniaceae: *Polemonium reptans* L., *Phlox divaricata* L., *P. maculata* L. Hydrophyllaceae: *Hydrophyllum appendiculatum* Michx., *H. canadense* L., *H. macrophyllum* Nutt., *H. virginianum* L., *Phacelia Purshii* Buckl. Boraginaceae: *Echium vulgare* L., *Lithospermum arvense* L., *Cynoglossum officinale* L., *Mertensia virginica* (L.) Pers., *Hackelia virginiana* (L.) I.M.Johnston. Verbenaceae: *Verbena canadensis* (L.) Britt., *V. hastata* L., *V. simplex* Lehm., *V. stricta* Vent., *V. urticifolia* L., *V. urticifolia* var. *leiocarpa* Perry and Fern., *Lippia lanceolata* Michx.

Labiatae: *Isanthus brachiatus* (L.) BSP., *Teucrium canadense* L., *T. occidentale* Gray, *Scutellaria incana* Biehler, *S. lateriflora* L., *S. ovata* Hill, *Marrubium vulgare* L., *Agastache nepetoides* (L.) Ktze., *Nepeta Cataria* L., *Glecoma hederacea* L. var. *micrantha* Moricand, *Prunella vulgaris* L., *P. vulgaris* var. *lanceolata* (Bart.) Fern., *Physostegia virginiana* (L.) Benth., *Synandra hispidula* (Michx.) Baill., *Leonurus Cardiaca* L., *Lamium amplexicaule* L., *L. purpureum* L., *Stachys Riddellii* House, *S. tenuifolia* Willd., *S. tenuifolia* var. *platyphylla* Fern., *Monarda clinopodia* L., *M. fistulosa* L., *M. fistulosa* var. *mollis* (L.) Benth., *Blephilia ciliata* (L.) Benth., *B. hirsuta* (Pursh) Benth., *Hedeoma pulegioides* (L.) Pers., *Satureja arkansana* (Nutt.) Briq., *Pycnanthemum virginianum* (L.) Durand & Jackson, *Lycopus americanus* Muhl., *L. rubellus* Moench, *L. uniflorus* Michx., *Mentha piperita* L., M. rotundifolia (L.) Huds., *M. spicata* L., *Collinsonia canadensis* L. Solanaceae: *Solanum carolinense* L., *S. Dulcamara* L., *S. nigrum* L., *Physalis pubescens* L., *P. virginiana* Mill., *Lycium halimifolium* Mill., *Datura Stramonium* L.

Scrophulariaceae: *Verbascum Blattaria* L., *V. Thapsus* L., *Linaria vulgaris* Hill, *Chaenorrhinum minus* (L.) Lange, *Collinsia verna* Nutt., *Scrophularia marilandica* L., *Chelone glabra* L. var. *linifolia* Coleman, *Penstemon Digitalis* Nutt., *Mimulus ringens* L., *Conobea multifida* (Michx.) Benth., *Veronicastrum virginicum* (L.) Farw., *Veronica Anagallisaquatica* L. f. *anagalliformis* (Boreau) G. Beck, *V. arvensis* L., *V. officinalis* L., *V. serpyllifolia* L., *Gerardia purpurea* L., *Pedicularis lanceolata* Michx. Orobanchaceae: *Epifagus virginiana* (L.) Bart. Acanthaceae: *Justicia americana* (L.) Vahl., *Ruellia caroliniensis* (Walt.) Steud., *R. strepens* L. Phrymaceae: *Phryma Leptostachya* L. Plantaginaceae: *Plantago aristata* Michx., *P. lanceolata* L., *P. Rugelii* Dcne. Rubiaceae: *Galium Aparine* L., *G. asprellum* Michx., *G. circaezans* Michx. var. *hypomalacum* Fern., *G. concinnum* T. & G., *G. triflorum* Michx., *Mitchella repens* L., *Houstonia caerulea* L.

Caprifoliaceae: *Triosteum angustifolium* L., *T. aurantiacum* Bickn., *T. perfoliatum* L. Valerianaceae: *Valeriana officinalis* L., *V. pauciflora* Michx., *Valerianella chenopodifolia* (Pursh) DC., *V. intermedia* Dyal., *V. olitoria* (L.) Poll. Dipsacaceae: *Dipsacus sylvestris* Huds. Cucurbitaceae: *Sicyos angulatus* L., *Echinocystis lobata* (Michx.) T. & G. Campanulaceae: *Specularia perfoliata* (L.) A. DC., *Campanula americana* L., *C. aparinoides* Pursh, *Lobelia Cardinalis* L., *L. inflata* L., *L. Kalmii* L., *L. siphilitica* L., *L. spicata* Lam. var. *campanulata* McVaugh.

Higher Fungi of Marion County, Indiana, VIII

JOHN O. COTTINGHAM, Indianapolis

This is the eighth report of the Higher Fungi of Marion County, Indiana, contains nine species, making a total of three hundred eighty-seven species thus far found and identified:

Agaricaceae

- Coprinus rotundasporus Pk.
- Clitocybe ditopoda Fr.
- Russula variata Bann
- Psathyrella longipes
- Lepiota Friesii Lasch

Boletaceae

- Boletus collinitus Fr.
- Boletus nigrellus Pk.

Hydnaceae

- Hydnum auriscalpium L. ex Fries

Discomycetes

- Durandiomyces Phillipsii Seaver

I am indebted to Mr. and Mrs. J. C. Tacoma, of Indianapolis, for supplying Clitocybe ditopoda and Hydnum auriscalpium.

Analysis of Some Natural and Artificial Interspecific Hybrids in *Helianthus*[1]

R. C. Jackson[2] and A. T. Guard

The importance of natural hybridization and subsequent introgression as a source of raw material for evolution has been stressed by Anderson (1949) and other workers in this particular field. Heiser (1947, 1949, 1951a, b) has demonstrated that *Helianthus annuus* L, the common sunflower, hybridizes naturally with other annual species. Long (1955a, b) and Jackson (1955) have shown that morphologically similar and dissimilar perennial species of Helianthus may hybridize readily.

This present study was initiated after observation of a large number of herbarium specimens indicated that *Helianthus mollis* Lam. was hybridizing naturally with several other perennial taxa. Descriptions of some of these hybrids have been reported in a previous paper (Jackson and Guard, in press). The purpose of this paper is to present an analysis of certain artificial and natural hybrids centered about *Helianthus mollis.*

Methods and Materials

Mass collections of the species and hybrid were made from various localities in Indiana. Collections of each species usually consisted of 25 individual plants from a single population. From 25 to 50 hybrid plants per population were collected, the number being dependent upon the size of the population and the variability present.

The sources of the natural hybrids and species used in this study are given in table 1.

Material for cytological study was collected from naturally occurring species and hybrids and from artificial hybrids and the parental species grown in the greenhouse. Immature heads were fixed in a mixture of two parts absolute ethyl alcohol and one part glacial acetic acid. After 48 hours, the microsporocytes were squashed directly in iron-acetocarmine. Usable slides were made permanent by the introduction of Venetian turpentine. Pollen grains were stained with 5 percent cotton blue in Aman's Lactophenol. Only those pollen grains with the cytoplasm stained in a uniform deep blue after 48 hours were considered viable.

Artificial crossing was accomplished by rubbing the heads of the plants together during anthesis of the disc flowers. Plants were bagged before and after crossing in order to insure against pollen contamination from other plants.

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[1] A portion of the field work for this study was made possible by a grant from the Indiana Academy of Science.

[2] Present address: Dept. of Biology, University of New Mexico.

TABLE 1

Sources of the Species and Hybrids Used in This Study[1]

Species or Hybrid	Number	Collector	Locality
H. mollis	p72	C. B. Heiser	N. St. Louis, Mo.
H. mollis	p171	H. Iltis	Rootsfork, Ark.
H. mollis	716	R. C. Jackson	Tippecanoe Co., Ind.
H. grosseserratus	p54	M. Ownbey	Ft. Smelling, Minn.
H. grosseserratus	717	R. C. Jackson	Pulaski Co., Ind.
H. giganteus	p3250	C. B. Heiser	Camp Douglas, Wis.
H. giganteus	726	R. C. Jackson	Starke Co., Ind.
H. divaricatus	727	R. C. Jackson	Starke Co., Ind.
H. atrorubens	p44	Baldwin	Virginia
H. mollis X *H. grosseserratus*	700	R. C. Jackson	0.8 mi. N. of Chalmers, White Co., Ind.
H. mollis X *H. giganteus*	706	R. C. Jackson	0.4 mi. N. Bass Station, Starke Co., Ind.
H. mollis X *H. giganteus*	710	R. C. Jackson	1 mi. S. of San Pierre, Starke Co., Ind.
H. mollis X *H. divaricatus*	714	R. C. Jackson	Jasper-Pulaski State Game Preserve, Pulaski Co., Ind.
H. mollis X *H. divaricatus*	715	R. C. Jackson	1 mi. S. of San Pierre, Starke Co., Ind.

[1] All plant numbers preceded by p represent collections kindly furnished to the writers by Dr. C. B. Heiser, Jr., Indiana University.

Cytological Observations

The species studied here all have the reported haploid chromosome number of seventeen. These counts were verified during this study. Meiotic stages beginning with diakinesis and containing through anaphase II were studied in the species and hybrids. Observations on pairing were made exclusively at diakinesis since this was the only stage where the chromosome pairs could be spread out sufficiently for detailed study.

As a measure of pairing in the earlier stages, the mean minimum chiasma frequency at diakinesis was used. Closed bivalents were considered as being held together by a single chiasma at either end while open bivalents were treated as being held together by a single chisma. Most of the closed bivalents were circular in shape and the open bivalents were held together at one end. No univalents were observed in any of the hybrids or species reported here. The chiasma frequency and pollen fertility of the species and hybrids are given in table 2. Standard error was calculated for chisma frequency.

TABLE 2

Mean Minimum Chiasma (Xa.) Frequency Per Cell and Pollen Fertility of the Species and Artificial Hybrids[1]

Species and Hybrids	No. of cells studied	Xa. frequency		% Stainable Pollen
		range	x s	
H. mollis (p72)	50	20–29	28.7+1.8	97.0
H. mollis (p171)	50	29–26	22.5+1.5	98.9
H. grosseserratus (p54)	50	21–28	23.8+2.0	99.7
H. divaricatus (727)	50	20–26	22.6+1.2	100.0
H. giganteus (p3250)	50	20–30	22.0+1.8	99.4
H. giganteus (726)	50	20–28	23.5+1.7	99.7
H. atrorubens (p44)	50	29–32	31.0+1.0	92.4
H. grosseserratus (p54) X *H. mollis* (p72)	50	20–27	22.4+2.0	94.4
H. mollis X *H. divaricatus* (727)	50	19–24	20.8+1.5	49.4
H. giganteus (p3250) X. *H. mollis* (p72)	50	20–26	22.9+1.6	59.7
H. mollis (p171) X *H. atrorubens* (p44)	72	17–22	18.9+1.5	34.0

[1] Cytological data for the hybrid between *H. mollis* and *H. divaricatus* are from a natural hybrid. The artificial hybrid has not yet been produced.

Cytology of the parental species: Meiosis was normal in *H. mollis*, *H. divaricatus* L., and *H. grossesarratus* Martens. In material from two of five plants of *H. giganteus L.* from a natural population a single chromatin bridge was observed in 5 of 25 cells at first telophase, but in plant p3250 used in the artificial crosses meiosis was normal. In *H. atrorubens* L. (p44) atypical meiotic behavior was noted. At early diakinesis chains of four chromosomes were seen in some cells. Fragments were observed at late diakinesis, metaphase I and anaphase I. A single chromatin bridge sometimes accompanied by a fragment was noted in 5 of 54 cells studied at first anaphase.

Cytology of the hybrids: Several natural hybrids between *H. mollis* and *H. divaricatus* were studied since the artificial hybrid has not yet been produced. In one plant a chain of four chromosomes was observed at diakinesis. No other aberrations were noted. In the artificial hybrid between *H. mollis* (p72) and *H. grosseserratus* (p54) all phases of meiosis were normal. The aberrations observed in *H. giganteus* (p3250) X *H. mollis* (p72) have been reported previously (Jackson, 1956). Briefly, fragments were found at early diakinesis and at first metaphase. A few single chromatin bridges were noted, and in one cell a double bridge was observed. Generally bridges were infrequent; apparently they break in early anaphase because the remnants of what appeared to be broken bridges were seen in a number of cells. The hybrid *H. mollis* (p171) X *H. atrorubens* (p44) exhibited fragments at metaphase

I, and a single chromatin bridge was observed at anaphases I and II. In several cells the bridge at first anaphase was accompanied by a fragment.

Analysis of Populations

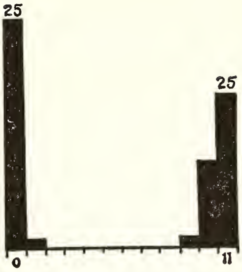
Species and natural hybrids from which population analysis were made were collected in Indiana during the summer and fall of 1953 and 1954. Analysis of artificial hybrids and backcrosses were made from plants grown in the greenhouses at Purdue University. Measurements of all plants were taken after they were pressed and dried.

The variation of morphological characters of the species and hybrids have been shown in histogram form using the Hybrid Index Method devised by Anderson (1936). It is a convenient way of graphically showing the differences within and between populations which are not easily grasped otherwise. The shortcomings of this method have been dealt with by Baker (1947), who criticized its use without adequate genetic data, by Heiser (1949) and by Anderson himself (1949). The method has been used extensively for studies of natural hybridization. In many of these studies artificial hybrids were not produced and the weighting of index values was arbitrary.

In this study all but one of the F_1 hybrids were produced, and a number of backcross progeny were grown and studied. By examination of the histograms in figure 8 it can be seen that F_1 hybrid between *H. mollis* and *H. occidentalis* reported elsewhere (Jackson and Guard, in press). *Helianthus giganteus* X *H. mollis* was an exception. This hybrid (fig. 4) resembled the pistillate parent more than the pollen parent. Thus, in examining histograms of natural hybrid populations, one should always refer to the position of the F_1 hybrid scored by the same index. Variation to the right or left of the F_1 may be taken as an indication that introgression has occurred in a particular direction.

Parental species populations: Several populations of each species were sampled, but only one for each species has been used for the histograms presented in this section. Variation between populations in which hybridization had occurred was generally slight, and could most easily be attributed to edaphic or physiographic factors.

Although most of the species discussed here are found in northern Indiana, they do not always grow in the same habitat. Ecological or physiological barriers serve to keep them separated. *Helianthus mollis* is generally a prairie species and occurs in greatest abundance in this habitat. In regions of extensive cultivation it is limited to fence rows and railroad right-of-ways. Smith (1952) has discussed the ecology of *H. divaricatus* in some detail. Generally this species has been observed growing in open sites, usually along wooded areas. Where the species grows in the open, it is usually more vigorous and has more flowers than plants growing in partial shade. *Helianthus giganteus* is usually found in wetter habitats than the other species. In northern Indiana it has been collected in bogs, along lake edges, along streams, and in low wet pastures. The habitat requirements of *H. grosseserratus* are much the same as *H. mollis*, and the two are frequently found in extensive stands along railroad tracks in the Lake Area. *Helianthus atrorubens*



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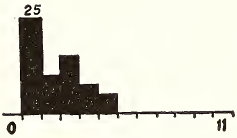

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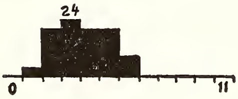

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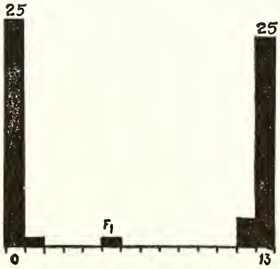

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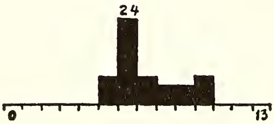

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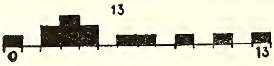

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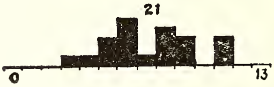

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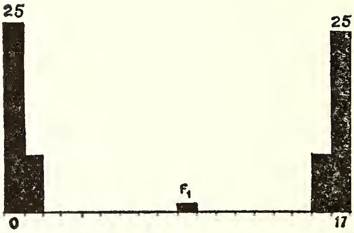

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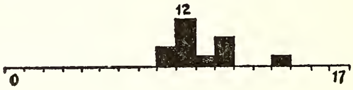

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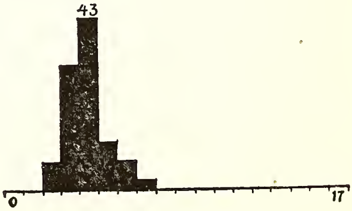

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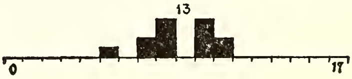

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occurs mostly in dry open habitats along roadsides, in open pine woods, and low wet areas in the Atlantic coast region from New Jersey southward.

The flowering periods of the species considered here may overlap one another at times. The earliest species to flower is *H. divaricatus.* Anthesis has been known to occur as early as the first week in July in Indiana. One population of this species growing in an open disturbed area was observed to flower through the 27th of August, and in this same area the species hybridized with *H. mollis. Helianthus mollis* has been collected in full flower in the last week of July. In some areas flowering may extend through the middle of August, and frequently into September when the plants have been mowed. The flowering period of *H. giganteus* is about the same as *H. mollis.* In *H. grosseserratus* anthesis generally occurs from the last of August through September.

Where the histograms of the parental species are shown *H. mollis* is always the histogram farthest to the right. The total number of plants scored is indicated above each histogram. Histograms of the parental species are shown in figures 1, 4, and 8.

Natural hybrid populations: The characters used for scoring the plants are given separately for each hybrid combination. The same population of *H. mollis* has been used for comparison with the other species throughout. In each case it has been necessary to revalue the index scores according to the new index that was erected. This was necessary because characters clearly separating *H. mollis* from one species may be overlapping with another.

According to Anderson (1949), it is usually advisable to assign different score values to certain characters, either because they can be more accurately measured and so deserve more consideration as criteria, or because they are known to rest upon a wider genetic background. Some of the characters used here have been given higher index values because they are apparently controlled by multiple factors as indicated by backcross segregation. Other characters have been found to vary widely in hybrid populations while being restricted in species populations. Probably these variations in hybrid populations are

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Legends

General: Histograms of the species, artificial and natural hybrids, and the backcross progeny.

Fig. 1. *H. mollis* (716) to the right, *H. divaricatus* (727) to the left.
Fig. 2. *H. mollis* X *H. divaricatus* (715).
Fig. 3. *H. mollis* X *H. divaricatus* (714).
Fig. 4. *H. giganteus* (726) to the left, *H. mollis* (716) to the right, and the F_1 hybrid between the two species.
Fig. 5. *H. (mollis* x *giganteus)* X *H. mollis.*
Fig. 6. *H. mollis* X *H. giganteus* (706).
Fig. 7. *H. mollis* X *H. giganteus* (710).
Fig. 8. *H. grosseserratus* (717) to the left, *H. mollis* (716) to the right, and the F_1 hybrid between the two species.
Fig. 9. *H. mollis* X *H. grosseserratus* (700).
Fig. 10. *H. (grosseserratus* x *mollis)* X *H. grosseserratus.*
Fig. 11. *H. (grosseserratus* x *mollis)* X *H. mollis.*

also due to multiple gene inheritance, and they have accordingly been given higher index values.

In the measurements, leaf base angle or a combination of leaf base and apex angles were used. The leaf base angle is the angle between the line of the midrib of the leaf, and a line from the point of attachment of the leaf to the stem, to the widest point on the leaf blade. The leaf apex angle is obtained in much the same manner, beginning at the leaf apex. The leaf index is the leaf length divided into the leaf width.

Helianthus mollis X. *H. divaricatus:* Three populations of hybrids were found, and two were sampled. The characters used for scoring the parental species and hybrids, and their index scores are as follows:

H. divaricatus			Intermediates	*H. mollis*
Head dia. in mm.	9-12	(0)	13–14.9 (1)	15–20 (2)
Ray number	8-13	(0)	14–16 (1)	17–22 (2)
Leaf index	.26-.36	(0)	.37–.42 (1)	.43–.68 (2)
Leaf apex angle	9.14°	(0)	15–17.9°(1)	18–26°(2)
Stem pubescence	0	(0)	1(1), 2(2)	3(3)

Population 715 was growing on sandy soil deposited from the excavation of a drainage ditch where the ditch passed a small wooded area. *Helianthus divaricatus* grew along the edge of the woods in its typical habitat, and *H. mollis* occurred in the open along a railroad track that paralleled the ditch. The hybrid population was rather small and showed a decided variation toward *H. divaricatus* (fig. 2). Some of the plants could be separated from *H. divaricatus* only by the pubescence of the stem. In population 714 the variation toward *H. divaricatus* was again quite pronounced, but not as much as in 715. Individuals of 714 were growing along a fireroad on the Jasper-Pulaski State Game Preserve. The habitat was similar to population 715. A sample collection from 714 is shown as a histogram in figure 3.

Helianthus mollis X *H. giganteus:* The characters used for scoring the parental species and hybrids, and their index values are as follows:

H. giganteus			Intermediates	*H. mollis*	
Head dia. in mm.	8-12	(0)	13–14.9 (1)	15–20	(2)
Leaf index	.14-.20	(0)	.21–.23(1), .24–30(2), .31–.42 (3)	.43–.68	(4)
Leaf base angle	10-19°	(0)	20–24°(1), 25–29°(2) 30–33° (3)	34–50°	(4)
Stem pubescence	(1)	(0)	2(1), 3(2)	4	(3)

Two hybrid populations were sampled. Three more were found but these consisted of very few clones. Population 706 was growing along a small highway drainage ditch. All the plants in the population were collected for study. Two of the plants were the parental species and the hybrids showed a range of variation between the two parental species (fig. 6). Population 710 was growing on sandy soil from a recently dug ditch. Both parental species were growing in the same vicinity, but *H. giganteus* was represented by fewer individuals. Variation in this population was stronger in the direction of *H. Mollis* (fig. 7).

The two parental species here are invariably ecologically separated. *H. giganteus* occurs in decidedly wet habitats while *H. mollis* is found in drier sites. All hybrids found in this study appear to result from the invasion by *H. mollis* into wetter areas along the levees of drainage ditches. Wherever it comes into close proximity with H. giganteus hybridization occurs. Natural hybrid derivatives from such crosses have in the past been designated under the epithet *H. doronicoides* Lam., and the species name was undoubtedly applied to such a natural hybrid (Jackson, 1956).

The F_1 hybrid between *H. giganteus* and *H. mollis* was backcrossed to *H. mollis*. The progeny are represented by the histogram in figure 5. As may be expected, there was a definite trend in variation toward the recurrent parent.

Helianthus mollis X *H. grosseserratus:* The characters used for scoring the parental species and hybrids and their index values are as follows:

	H. grosseserratus		Intermediates	*H. mollis*
Head dia. in mm.	9-13	(0)	13.1–14.9 (1)	15–20 (2)
Ray number	10-14	(0)	14–15 (1)	17–20 (2)
Leaf index	.10-.16	(0)	.17–26(1), .27–.33(2), .34–.42(3)	.43–68 (4)
Length to lateral veins in cm.	4.3-7.5	(0)	1.4–4.2 (1)	.5–1.3 (2)
Leaf base angle	7-13°	(0)	14–24°(1), 25–33°(2)	34–50°(3)
Stem pubescence	0	(0)	1(1),2(2),3(3)	4 (4)

Population 700 (fig. 9) was scored on a scale of 0 to 17 using all the characters listed above. Most of the individuals of this population were varying toward *H. mollis* or were like an F_1 hybrid in index value.

The F_1 hybrid between *H. mollis* and *H. grosserserratus* was backcrossed to each of the parents. In the backcross to *H. grosseserratus*

60 plants were obtained. Two plants died in the seedling stage and some did not flower. The histogram based on this backcross is shown in figure 10. In the backcross to *H. mollis* 25 plants were obtained. Of these, three had not grown beyond the rosette stage at the time the others flowered, and six of them were under 26 cm. in height, showing no evidence of flowering. The histogram representing the remainder of the progeny is shown in figure 11.

In both backcrosses a series of pubescence grades ranging from 0 to 3 was discernible. A gradation was also observed for leaf index and leaf base angle. Some of the backcross progeny from the cross to *H. grosseserratus* resembled that species very closely. Possibly they would have been determined as this species by casual examination in the field. Other of the backcross progeny were quite similar to *Helianthus brevifolius* E. E. Wats., and in the opinion of the writers the species named by Watson (1929) is a hybrid derivative from a cross between *H. mollis* and *H. grosseserratus*. Inasmuch as *H. brevifolius* is believed to be of hybrid origin it is herein reduced to hybrid status:

Helianthus X *brevifolius* E. E. Watson (pro sp.)

Helianthus brevifolius E. E. Wats. Pap. Michigan Acad. 9: 305-475. 1929.

Discussions and Conclusions

The species studied here are morphologically distinct taxa. However, all are interfertile and the F_1 hybrids between them are as vigorous or more vigorous than the parental species. There was a range of stainable pollen in the hybrids of 34 percent in *H. mollis* X *H. atrorubens* to 94.4 percent in *H. mollis* X *H. grosseserratus*. This was generally a much higher pollen fertility range than has been found in interspecific hybrids of annual species of *Helianthus* (Heiser, 1949, 1951a, b).

Probably the primary cause of reduction in fertility of the hybrids is a certain amount of chromosomal repatterning. This was indicated by translocation configurations in *H. mollis* X *H. divaricatus* and has also been found in *H. mollis* X *Hoccidentalis* (Jackson and Guard, in press). Translocation configurations were also found in *H. atrorubens*. Evidence for an inversion difference was found in *H. mollis* X *H. atrorubens* and in *H. giganteus* X *H. mollis*. However, it will be recalled that this type of configuration was found in both *H. atrorubens* and *H. giganteus* so that it may represent an intraspecific as well as an interspecific difference. Chromosomal repatterning within and between plant species is not an uncommon phenomenon as indicated by the numerous examples cited by Stebbins (1950) and Clausen (1951). Thus far, changes in chromosome structure have not been sufficient to exclude gene flow between the perennial species of *Helianthus* in which hybridization has been found to occur. In the crosses of *H. mollis* to *H. divaricatus*, *H. grosseserratus*, and *H. giganteus* the difference in mean minimum chiasma frequency of the parental species and hybrids was not significant. This indicates a rather high chromosome homology of the species.

There appear to be several types of isolating mechanisms which tend to keep some of these species separated. For the most part they fit into the classification given by Stebbins (1950, p. 196) in that both external and internal barriers are present. *Helianthus mollis* and *H. atrorubens* are generally spatially isolated with the latter found in the southeastern part of the United States while the former is mostly a prairie species. This separation may have been for a considerable length of time, but the species are still infertile and the artificial hybrid was vigorous and formed 34 percent stainable pollen.

Helianthus grosseserratus and *H. divaricatus* are partially isolated from *H. mollis* by blooming dates, but occasionally the two overlap with *H. mollis* enough for hybridization to occur. In disturbed areas the flowering of *H. divaricatus* is prolonged by the increased vigor of the plant when it grows in the open. This allows for an overlapping with *H. mollis* and subsequent hybridization. The one natural hybrid swarm between *H. mollis* and *H. grosseserratus* was probably due to mowing of *H. mollis* with the result that new lateral branches that developed flowered at the same time as *H. grosseserratus*. *Helianthus giganteus* grows in decidedly wetter habitat than *H. mollis* but hybrids are found along drainage ditches and other such disturbed areas that provide habitats for both species to grow in close proximity.

Internal barriers in the backcross progeny include three of the four types listed by Stebbins (1950). In backcross progeny of the hybrids *H. mollis* X *H. grosseserratus* and *H. mollis* X *H. giganteus* a few of the plants had little or no stainable pollen (Table III). Hybrid sterility in the backcross hybrid of *H. grosseserratus* X *H. mollis* was probably genic. In the backcross *H. (giganteus* x *mollis)* X *H. mollis* the cause of sterility may have been both chromosomal and genic. Weak individuals and failure of flowering occurred in some of the backcross progeny of the hybrid between *H. mollis* and *H. grosseserratus*. In all the F_1 plants hybrid sterility occurred in varying degrees, but they were quite vigorous and flowered prolifically.

Introgression in some of the natural hybrid populations reported here may not, as yet, be of great biological significance, but the foundation for further introgression is certainly present. Apparently the flow of genes between populations is still confined to rather small areas.

An important question concerning species formation in *Helianthus* is how so many species have evolved which have a sympatric distribution. The hypotheses held by Dobzhansky (1941), Mayr (1942), and Muller (1942) is that in sexually reproducing, cross-breeding organisms geographic isolation must precede the formation of other isolating barriers. This hypotheses would seem to apply to diploid perennial species of *Helianthus*, although according to Stebbins (1950) sympatric speciation in cross pollinated perennial species is theoretically possible. According to Dobzhansky and others, it can be inferred that the perennial species of *Helianthus* were at one time isolated. This has not resulted in much sexual separation of the species because they are generally rather highly interfertile. However, when one compares the morpholigical dif-

TABLE 3

Distribution of Percentage of Stainable Pollen Among the Progeny of Backcrosses

Backcross	Number of Plants	Percentage range of Stainable Pollen
H. (mollis x *giganteus)* X *H. mollis*	3	0
	2	13.7 – 20.0
	3	40.6 – 49.9
	2	52.0 – 59.6
	3	65.6 – 69.1
	2	83.8 – 87.6
	2	92.4 – 94.6
H. (grosseserratus x *mollis)* X *H. mollis*	6	55.5 – 77.6
	2	83.6 – 88.1
	3	91.6 – 98.1
H. (grosseserratus x *mollis)* X *H. grosseserratus*	2	0 – 1.2
	1	49.2
	2	72.0 – 74.3
	7	84.2 – 88.6
	16	92.3 – 99.3

ferences between interfertile species, it appears that genetic changes affecting morphological characters have been numrous. On the basis of evidence acquired through this study and from results of other workers, one can conclude that in *Helianthus* speciation has resulted in many morphologically distinct taxa which are still quite closely related genetically.

Such a situation may be of an advantage to the genus. Some of the species are sympatric in distribution but separated ecologically, and others are spatially isolated. However, man is destroying well-defined habitats and creating new ones, and he is introducing species into areas where they did not previously occur. Interspecific hybridization has been reported for many areas and doubtless occurs in others. The result of hybridization and introgression may well be the formation of new types or taxa which have slightly different habitat requirements and are thus able to exploit the new environments which have been produced.

Summary

Helianthus mollis has been found to hybridize naturally with a number of other perennial species. Natural hybrid populations have been analyzed by the Hybrid Index Method. Introgression has occurred in the examples studied, but it may not yet be of biological significance. Artificial hybrids and some backcrosses have been produced. Most of the F_1 hybrids were intermediate between the two parents. The exception to this was *H. giganteus* X *H. mollis* which resembled *H. giganteus* more closely. Some of the backcross progeny resembled the recurrent parent and a number showed various gradations between the species for key characters. Cytological studies of the species and hybrids have shown that a limited amount of chromosomal repatterning has occurred between and within the species. This has resulted in varying amounts of sterility, particularly in interspecific crosses. Little reduction in chiasma frequency of the hybrids indicate that the chromosomes of the parental species are still rather highly homologous. Isolating mechanisms and their effect on the separation of the species have been discussed. It is suggested that ecological isolating barriers are no longer as strict as they once were, due to the influence of man on the plant environment. From the evidence at hand, it appears that speciation in *Helianthus* has resulted in numerous morphologically distinct taxa which are still closely related genetically.

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Botanical Forays to Florida

LOIS FARQUHARSON,[1] Franklin College and MILLARD S. MARKLE,
Earlham College

At Indiana University and at Earlham College "forays" or field trips to Florida have been initiated in the past few years, and it was felt that members of the Taxonomy Division of the Indiana Academy of Science would be interested in knowing more about these trips—their "clientele," cost per student, places visited, traveling and living arrangements, and most important of all, the values of such trips. The following questions and their answers are an attempt to compare and contrast the trips.

Question 1) How many students and what kind of students went on the trips?

Dr. Farquharson: From ten to fourteen Indiana University students usually take the trip, and the background of these students varies considerably from year to year. Graduates and undergraduates in botany, as well as graduate students in education, have composed the group.

Dr. Markle: Twelve to eighteen students have gone on the trip, and they have nearly all been juniors and seniors, and many of them members of the class in field botany, which is ecological and taxonomic in scope. All have been majors in biology, with varied main interests—plants, birds, reptiles, shells, photography.

Question 2) When or what time of year did you go and how long a trip was it?

Dr. Farquharson: We make the excursion during the latter half of August, chiefly because it fits into the Indiana University two-week short session after the regular summer school courses end. It has turned out to be a satisfactory time of year, Florida not being any more uncomfortable than southern Indiana during the summer. Then too, many plants are in fruit, and frequently we are able to take advantage of off-season motel rates.

Dr. Markle: The trip is taken during a twelve-day spring vacation, the last of March and early in April. This is a trifle early for the northern part of the area, especially Okefenokee Swamp, but it is a fine time for birds and plants in Florida.

Question 3) Where did you go and what were some of the interesting stops?

Dr. Farquharson: The trip is usually routed through the Great Smoky Mountains, and the first extensive stop is in southern Georgia where the Okefenokee Swamp and a lumber mill are visited. Then we travel south along the east coast of Florida, stopping in St. Augustine to see places of historical interest as well as plants. From headquarters in Homestead, side trips are taken into the Everglades, out on the Keys and to several botanical gardens in the Miami-Homestead area, including the Subtropical Experiment Station near Homestead which has many interesting fruits. Crossing the Tamiami Trail and turning north, stops are made for cypress knees near Palmdale, gardens in St. Petersburg, and carnivorous plants in northern Florida. In Alabama some time is spent observing crops such as cotton, sugar cane and peanuts.

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[1] At the suggestion of Dr. Paul Weatherwax, Dr. Farquharson presented the material for the trips which Dr. Weatherwax conducts at Indiana University.

Dr. Markle: The trip is mostly routed through the interior of Florida, avoiding populated areas. We visit the shores of Sanibel or of Marko Islands for shells, cypress swamps near Immokalee, Everglades National Park. The Everglades boat trip was disappointing this last year. Interesting stops and good overnight headquarters were found at Osceola National Forest, beach near Marineland, Highland Hammock State Park, Alexander's Springs. Hamlet's Birds of Prey Institute, Ross Allen's Reptile Institute were other stops of interest, and Hialeah was good for flamingoes. The area south and west of Lake Okeechobee was good for plants but particularly good for birds as was the area near and south of the Tamiami Trail from Monroe Station.

Question 4) How much did the trip cost per student and how did you travel and what were the "living" arrangements for food and shelter?

Dr. Farquharson: The trip costs approximately $110-$120 per student. This figure includes tuition and a share of the gas and oil expenses as well as food and lodging costs. We stay at motels and eat in restaurants rather than camping out, largely to save time and simplify the organization of the trip.

Dr. Markle: The trip costs approximately $35-$40 per student. We go in private cars and drivers are paid for gas and oil. Our trip is not connected with a course, hence no credit and no charge for tuition. Students sleep in sleeping bags, instructors in a Nash car. We use State Parks or other camping areas which provide good camping facilities. Much of the food is provided by the college at wholesale rates, and fresh fruits and vegetables are purchased en route. Breakfast and the evening dinner meal are prepared in camp by "meal squads" of three students. Lunch is prepared at breakfast time, and taken in the cars, therefore avoiding the necessity of time out for preparation at noon.

Question 5) What do you consider are the chief values of such trips?

Dr. Farquharson: 1. The students gain an appreciation of an entirely different part of the country—its history, geology and people as well as the plants of the area.

2. Many profit from the experience of learning to get along with others in such a group.

3. Botanically, the trip provides an excellent opportunity to survey the plant kingdom (from marine algae along the Keys, through the lower vascular plants such as *Psilotum*, *Lycopodium* and *Selaginella*, to the *Cycadales* and the flowering plants) and to study plants of agricultural and horticultural importance.

Dr. Markle: 1. Learning to live and work together on a group project.

2. The direct observation of nature by a group with varied interests, who learn from one another. Contact with unfamiliar habitats.

3. Learning the techniques of collecting, preserving or maintaining alive specimens of a great variety of plants and animals, previously largely unknown.

Variation in the Genus *Hudsonia*

MARION T. HALL, Butler University

Hudsonia, in the small family Cistaceae, contains three species all restricted to North America where they grow in sandy areas. These plants are small xerophytic shrubs, rather bushy with fine heath-like foliage, bearing leaves which are downy, small, sessile, appressed, persistent and alternate on the stems and bearing many bright-yellow flowers, borne singly at the ends of short branches. The most widely distributed species, *Hudsonia tomentosa* (commonly called Beach-heath), occurs from Nova Scotia south along the Atlantic coast to Virginia and west along lake-shores, river-banks, and sand-hills to northern Alberta and south to the southern shores of Lake Michigan and Lake Erie. *Hudsonia ericoides* (known as Golden-heather) is the type species and occurs in Newfoundland, Prince Edward Island, and along the Atlantic to Virginia. The most restricted species, *Hudsonia montana* apparently occurs only on Table Mountain in North Carolina.

On the sandy shores of Lake Pleasant, Hamilton Co., New York, Charles H. Peck, State Botanist of New York, in 1891 found a plant closely resembling *H. tomentosa.* He wrote in the New York State Museum Report, "The plants in their remarkably inland station differ so much from the typical form of the species that I am disposed to consider them a good variety. They are intermediate between *H. tomentosa* and *H. ericoides* and may therefore bear the name var. *intermedia.* Stems and branches more slender and longer; leaves narrow, less imbricating and less tomentose; flowers or pedicels mostly a little longer than the leaves."

Since Peck's description the var. *intermedia* has been found inland to the Great Lakes, to Lake Athabaska and the McKenzie Basin. I have made a survey of the area east of the Great Lakes, collecting population samples of *Hudsonia* in order to determine the distribution of var. *intermedia* and the nature of the variation within the species. Nearly 200 population samples, representing nearly 6,000 individuals, have been collected and are being analyzed by multiple correlation techniques, using four of the key characters. The basic trends seem quite clear.

I consider *Hudsonia tomentosa* var. *intermedia* to be a putative hybrid between *tomentosa typica* and *H. ericoides.* The variety shows recombinations of characters from both species. Their distribution supplies further evidence that the var. *intermedia* is an introgressant or backcross from hybridization. The two species, even though their ranges overlap in part, are ecologically isolated one from another. Wherever each grows separately, either species is very homogeneous; but where they grow together, each is very variable, and Peck's var. *intermedia* occurs abundantly along with other variants. In so far as I know, the two species occur together only in areas where man has made changes which suited them. *Hudsonia tomentosa* typica grows only in open dune blowouts along the Atlantic coast, on the sand deposits of the St. Lawrence Gulf, and inland to Lake St. John, particularly, in areas characterized by halophytic plants such as *Ammophila breviligulata, Juncus balticus* var. *littoralis, Lathyrus japonicus* var. *glaber* and/or var. *pellitus,* and *Triglochin maritma. Hudsonia ericoides* grows in the sandy, acid, pine-lands well inland from the coastal dunes. The only places the species occur together are along open, sandy highway shoulders running between the coastal dunes and the pine-lands and here one finds many hybrids. From these "centers" of variability the var. *intermedia* becomes established in the pine-lands but not in the open dune blowouts.

The continental distribution of *Hudsonia,* that is around the Great Lakes to the McKenzie Basin, consists almost entirely of the var. *intermedia* which is found there in sandy pine-lands. In extensive open dune areas the typical variety may be found. It seems evident that var. *tomentosa,* endowed with a few genes of *ericoides,* was able to conquer a new habitat.

The origin of var. *intermedia* is probably not a recent development, i.e., since man built his coastal highways; but more likely in post-Pleistocene, as a result of glacial disturbances of the landscape, opportunity probably existed for these species to hybridize and for the new ecotype to become established.

This paper is based on the study of population samples and herbarium sheets collected throughout much of the range of the species. The data were analyzed by means of ordered value statistics. The means, their confidence limits, (95%), and standard deviations were obtained. Histograms and pictorialized scatter diagrams were made up from index values of five characters.

PSYCHOLOGY

Chairman: J. P. Egan, Indiana Uunversity

Kenneth M. Michels, Purdue University, was elected chairman for 1957

ABSTRACTS

The Criterion in Speech Communication in Noise. James P. Egan, Indiana University.—The importance of the operating characteristic in speech communication is discussed. Three situations are described in which communications operators must use a criterion. These three situations give rise to: (1) the receiver operating characteristic, (2) the source operating characteristic, and (3) the monitor operating characteristic.

On the Relationship between Kappa and Auditory Fatigue. James D. Miller, Indiana University.—A hypothesis is presented which attempts to account for the 4000 cps "dip" in the temporary hearing loss audiogram resulting from the exposure of the ear to uniform spectrum noise. This hypothesis states that the amount of temporary hearing loss, THL, observed at any frequency is determined by the level per cycle intensity of the noise, B; the width of the critical band in decibels, K; and the quiet absolute threshold, QAT; according to the equation:

$$THL = F(B + K - QAT).$$

Data are presented which show that while the hypothesis results in predictions showing the general contours of the observed temporary hearing loss audiograms, it consistently predicts too large THL's at the lower frequencies and too small THL's at the higher frequencies. The prediction is made by using the graph of the observed THL's at 4000 cps plotted against $(B + K - QAT)$.

Minimum Separable Acuity of Vision in the Raccoon. John I. Johnson, Jr., Purdue University.—To investigate the visual acuity of raccoons *(Procyon lotor)* as it pertains to laboratory testing situations, from the aspect of the minimum separation that can be detected, the chain pulling method of Warden, Fjeld and Koch was used. This method requires the animal to pull in that one of two chains to which a food cup is attached. The distance between the chains is systematically varied, and the relative success of the animal in choosing the correct chain at these various separation intervals provides an indication of his perceptual ability. All three raccoons tested were capable of discrimination when the distance between the chains, at the end where the food cup was attached, which was always 14 inches from the animal's eye, was 3 inches or more. Performance deteriorated progressively for smaller distances, although the evidence indicates that raccoons, at least occasionally, can at this distance discriminate separations as small as ¼ inch.

The Vocational Interest Patterns of Students Who Stay in Engineering Compared With Those Who Leave the Engineering Curriculum. N. M. DOWNIE, Purdue University.—Seven hundred and five students entering the engineering curricula of Purdue University in the fall of 1950 were given the Kuder Preference Record, Vocational. In th spring of 1954 a random sample of 90 students still in engineering and of 88 who had dropped from school was drawn. Eighty-eight other students who had changed from engineering to other schools of the university were also studied.

Means for these three groups on each of the scales of the Kuder were computed and tests for significant differences were made using F and "t" tests.

It was found that those students who remained in engineering scored significantly higher (1% level) on the scientific scale than the other two groups. These same students and those who had dropped from school both scored significantly higher (1% level) than those who had transferred on the computational key. The drop-outs scored significantly higher (5% level) than the transfers on the clerical key, and those still in engineering tended to score higher on this scale. Those who transferred (mostly to arts and sciences) scored significantly higher (5% level) than the other two groups on the literary scale. The students who left the university scored significantly higher (5% level) than those still in engineering on the artistic key. On the other scales there were no significant among the three groups.

The Scaling of Words to Describe Personality. ARNOLD BUSS and HERBERT GERJUOY, Carter Memorial Hospital, Indianapolis and Indiana University.—Adjectives descriptive of personality were scaled for intensity and abnormality by clinical psychologists. Prior to scaling, each adjective was assigned to one of 18 dimensions of personality. On each dimension intensity was taken to be a bi-polar attribute ranging from excess to deficiency; while abnormality was taken to be uni-polar, ranging upward from hypothetical zero abnormality. For the intensity scaling 42 judges rank-ordered the adjectives within each dimension. Hull's procedure was used to obtain scale values. For the abnormality scaling 24 judges rated each adjective on a scale from 1 to 9. Scale values were obtained by taking the means of the ratings. There was a high non-linear relationship between intensity and abnormality means. Minimum abnormality means were obtained for adjectives falling in the middle of the intensity scale, and large abnormality means were obtained for adjectives falling at either extreme of intensity. These scale values may be used to help set up a standard descriptive nomenclature in both clinical and research work involving personality description.

Reduction in Effect of Prior Exposure on Escape-from-Shock Training by Reduction in Duration of Pulse. JAMES A. DINSMOOR, Indiana University.—A technical difficulty which has arisen in escape-from-shock training studies is that prior exposure to inescapable shock slows down subsequent acquisition of escape behavior. This study is an attempt to reduce this "adaptation" effect by: (a) reducing the length of successive pulses of shock; and (b) depriving half the subjects of food.

Twenty-four male albino rats, aged about 4½ months, were used as subjects. The test procedure for all animals was a fifty minute session in the bar-pressing apparatus, in which each press-and-release sequence in the presence of 200 microampere shock terminated the shock for twenty seconds, followed by its reappearance. Seventy-eight pulses were presented per minute for each electrode in contact, with a pulse duration of .048 seconds. Half of the animals were exposed on the previous day to fifty minutes of inescapable 400 microampere shock, for a stringent test; their controls were placed in the apparatus with no charge on the grid. Further, half of each of these groups was fed ad lib, the other half maintained on a 1 hour feeding, 23 hour fasting cycle. Experimental sessions came immediately before feeding.

Non-reinforced responding prior to training was significantly ($p<.001$) higher for shocked than non-shocked animals. An analysis of variance for number of escape responses in training showed that prior exposure to shock remained a significant ($p<.01$) variable, even with the shorter pulse, but that the drive-exposure interaction fell short of significance. A comparison of the ad lib animals with corresponding animals from a previous study using the same conditions except for a 33⅓ per minute, .113 second shock pulse did show a significant ($p<.001$) interaction between pulse-duration and exposure, indicating that the reduction in pulse duration did reduce the "adaptation" effect.

Externally-aroused Drives in the Raccoon. RICHARD I. THACKRAY and KENNETH M. MICHELS, Purdue University.—The present study was designed to study the effectiveness of manipulatory objects as incentives for the learning of a simple position response. Using a single unit T-maze raccoons were tested with the stimulus objects located in one of the goal cages. After the learning series a reversal series was conducted following which satiation effects were studied. Both latency of entry into the correct goal cage and manipulation time were measured. While there were marked individual differences between animals, significant changes in latency were obtained during the learning and reversal series. For three of the animals a significant increase in manipulation occurred during the learning series followed by a significant decline during the satiation series.

The Relation Patterns of Magnitudes of the QRS Complex to Rote Learning. R. N. BERRY, Indiana University.—Continuous EKG records were obtained from 16 male *S*s during the learning of a nine item nonsense syllable list. Learning trials were given to a criterion of one correct trial. The magnitude of the QRS component of every heart beat was measured and plotted in relation to the action of the memory drum on which the syllables were presented. There appears to be a more orderly pattern of the QRS magnitudes as learning progresses, although the pattern differs from *S* to *S*. This finding will be presented in a qualitative way by showing the plotted data for selected trials. It will be suggested that part of the final pattern is a product of breathing patterns and that these are necessary for the appearance of the desired responses. It will be suggested even more generally that verbal learning is in part a matter of achieving coordination of the necessary muscle groups.

The Sampling of Common Elements in Discrimination Learning. DAVID L. LABERGE and ADRIENNE SMITH, Indiana University.—This experiment was an attempt to test the probability assumption of certain statistical learning models. The hypothesis derived from the assumption was that subjects responding at or very near unity to each signal in a discrimination task would not be sampling elements common to the signals.

The 207 subjects were given 284 trials on successive discrimination tasks of two levels of difficulty, both involving simple figures. Interspersed among these trials were test signals, involving background stimuli only. The mean proportion of A1 responses to these blank signals was taken as a measure of the status of the common elements. When the partial reinforcement schedule associated with background stimuli was abruptly changed, those *S*s which had reached a near unity level of responding did not change their level of response to the blank signals. This was interpreted as indicating that they were not sampling common elements and the probability assumption was therefore supported.

Terminal Probability of a Positional Response Following Three Types of Training. TERESA S. CARTERETTE, Indiana University.—A comparison was made of the mean terminal probability of a reinforced position response following training under three correction procedures and two reinforcement schedules. The aim was to investigate the applicability of statistical learning theory to acquisition in a T maze when the stimulus situation on training and test trials differs in varying proportions.

By placing a barrier in that arm of a T maze leading to the empty goal box, food deprived rats were trained to run into the goal box containing food reinforcement. The location of the barrier differed for each of three pairs of training groups. Barrier position determined the degree of similarity between the training and test trial situations. In the Correction Groups the rats could traverse the entire length of the maze arm leading to a locked empty goal box before turning to run into the arm leading to the goal box containing reinforcement. The rats in the Intermediate Correction Groups could travel over the first six inches of the maze arm leading to the empty goal box; and those in the Forced Groups could not enter this arm at all. Within each of these three training procedures, one group was continuously reinforced on one side; and the other group was randomly reinforced, 75% of the time on one side and 25% on the other. On test trials the maze was identical for all groups: either arm and goal box could be entered and neither goal box contained food. All groups received a twenty-three day Acquisition Series followed by a sixteen day Reversal Series. A correct response was a goal box entry on the predominantly reinforced side. Eighty-four female hooded rats were used.

The mean terminal probabilities for correct responding in the 100% groups corresponded in rank to the degree of similarity between training and test situations and ranged from .97 for the Correction Group to .77 for the Forced Group. No such ranking was observed for the 75% groups; but the mean terminal probability of a correct response in the Initial Series did not differ significantly from the probability of reinforcement. For both series, analyses of variance testing the overall differences among the mean terminal probabilities for correct responding yielded *F*'s significant at the 5% level of confidence only for the differences between reinforcement conditions.

The prediction from statistical learning theory that the probability of a response at the asymptote of learning will equal its probability of reinforcement was supported. Such departures as were observed in the 100% Forced Group can be encompassed by the model for simple two-choice learning if the difference between training and test trials is taken into account in the mathematical analogue of the experimental situation.

ZOOLOGY

Chairman: ENOS G. PRAY, Hanover College

ELIOT WILLIAMS, Wabash College, was elected chairman for 1957

ABSTRACTS

A Distributional Summary of the Herpetofauna of Indiana and Illinois. SHERMAN A. MINTON, JR. and PHILIP W. SMITH, Indiana University Medical Center, Indianapolis and Illinois Natural History Survey, Urbana, Illinois.—The distribution of 75 species of reptiles and amphibians whose ranges terminate in Indiana and Illinois have been analyzed. The ranges of the eastern and western species usually terminate within or near the zone of prairie-forest transition. Some western species are largely restricted to sand prairie. Northern and southern components of the herpetofauna are most strongly limited by the southern limit of the Wisconsin glaciation and by the northern limit of the austroriparian biotic province. Features exerting minor influence upon distribution of the herpetofauna are the southern boundary of Illinoisian glaciation, the borders of the Wabash lowland, and the southern boundary of the Great Lakes Plains. In general, aquatic species are influenced to a lesser degree than are terrestrial species.

Range edge patterns of most eastern and about half of the southern species suggest a fauna advancing with the last stage of forest succession. The northern, western, and a number of the southern species show a strong tendency toward fragmentation of range in our area. We interpret this as indication of withdrawal from formerly more extensive continuous ranges. Apparently some of these species are remnants of an early post-Wisconsin herpetofauna, others are relicts of a subsequent warm period, and others of an interval during which a grassland fauna dispersed eastward.

***Eugymnanthea*, the Hybrid That Lives in a Clam.** SEARS CROWELL, Indiana University.—*Eugymnanthea* is a solitary calyptoblastic hydroid first described by Palombi in 1935. It is known from only four locations: Naples and Taranto, Italy; Boqueron, Puerto Rico, and the vicinity of the Onomichi Marine Biological Station, Japan. At each location it has been described as occurring in a single but different pelecypod host. Recent observations by the author at Naples show, however, that it lives in several different clams: it is not as host specific as had been presumed.

This hydroid is interesting because of the large number of ways in which it differs from typical hydroids. These differences may be attributed to its commensal habit and to the difficulty of maintaining a foothold in the mantle cavity of its host. The polyp has a large basal disk. This not only holds fast to ciliated epithelia but by slow changes of shape enables the polyp to creep.

A sexual reproduction is accomplished by the development of a simple bud at the junction of the body of a polyp and its basal disk. After the bud becomes a small polyp the basal disk is pulled apart so that parent and offspring each obtain part of it.

The Puerto Rican species produces a typical leptomedusa, the medusa of the Italian species is mature at liberation and not well developed, the medusa of the Japanese form is unknown. Although the anatomy of the medusa relates *Eugymnanthea* to calyptoblastic hydroids the polyps are completely devoid of perisarc.

The embryology and the method of entrance to new hosts has not been studied.

Birds and Grasslands in Western Mexico. J. DAN WEBSTER, Hanover College.—The temperate grasslands of the Republic of Mexico constitute 22% of the country's area. Of these, the pure short grass plains along the eastern slopes of the Sierra Madre Occidental resemble the Great Plains of the United States in their biota. The birds of these and other kinds of Mexican grasslands are listed and discussed.

The Effect of Sex Steroids on the Gonadotrophic Content of Pullet Pituitary Glands. FRANK J. ZELLER and WILLIAM R. BRENEMAN, Indiana University.—There are two theories concerning the relationship of the anterior pituitary and the ovary. The "target-organ" theory states that it is the ovary which metabolizes the gonadotrophic hormones and this then is responsible for maintaining the titer level of these hormones in the blood stream. The "teeter-totter" idea is that as the concentrations of ovarian hormones increases in the blood stream they inhibit the production and release of the gonadotrophic hormones from the anterior pituitary gland.

In this experiment, greater than physiological doses of stilbesterol, testosterone and progesterone were injected into ninety-five day old pullets for ten days. The pituitary glands were then removed, weighed and assayed in newly-hatched cockerels to determine their gonadotrophic content. The different gonadal hormones failed to cause any appreciable change in pituitary weights as compared to control birds receiving just the hormone carrier, sesame oil.

The assay results showed that the pituitary glands from the stilbesterol (2500 ugm.) treated pullets contained the highest concentration of gonadotrophic hormones, causing an increase in gonad weight of the cockerels 156% above that of the control pituitary glands. The testosterone (500 ugm.) treated birds had one-half this amount, while the pituitary glands from the progesterone (600 ugm.) treated birds were no different in effect than the control birds.

This would seem to indicate that even large doses of stilbesterol, and possibly testosterone can stimulate the production of pituitary gonadotrophins while progesterone at this level has neither a stimulatory or inhibitory effect.

The Effect of Inhibitors on the Membrane Potential of Muscle Fibers of the Crab, *Carcinides maenas*.[1] WILLIAM K. STEPHENSON, Earlham College.—Muscle fibers of the shore crab, *Carcinides maenas*, maintain membrane potentials of 70 to 75 mV. for 3 to 7 hours after isolation to sea water. This electrical potential is maintained even though the fibers are losing potassium and gaining sodium. Addition of KCl to the sea water medium does not cause the reduction in potential expected for a potassium diffusion potential. The addition of 0.005 M. NaCN to the medium has no immediate effect on the potential. 0.001 M. dinitrophenol causes a 5 to 10 mV. reduction of potential over 2 to 3 hours. 0.005 M. iodoacetate brings about an immediate decline of potential of ca. 15 mV./hr. These results are consistent with the hypothesis that membrane potential is supported by energy derived from the anaerobic phase of metabolism.

A Purine and Pyrimidine Requirement for *Paramecium multimicronucleatum*. Charles A. Miller and Willis H. Johnson, Wabash College.—A medium has been developed for the axenic culture of *Paramecium multimicronucleatum* which is chemically defined except for one constituent—a nondializable fraction (NDF) of an exhaustively dialyzed yeast extract. Excellent growth was obtained by adding 1 mg. NDF per ml. to a basal medium of inorganic salts, sodium acetate, sodium pyruvate, stigmasterol, six B-vitamins and 17 amino acids. Several of these compounds have been shown to be essential for continued growth.

Recent studies confirmed an earlier finding by Johnson (1952) for the need of guanylic and cytidylic acids for this organism. Upon digestion of the NDF with crystalline ribonuclease and deoxyribonuclease, followed by redialysis of the digest, it was found that both the impermeable solution and the dialyzate were required for continued growth. Dry weights of these fractions indicate that the NDF contained as much as 25% nucleic acid with high amounts of deoxyribonucleic acid. The dialyzate fractions could be completely replaced with a mixture of purines and pyrimidines. A purine requirement could be satisfied by either guanylic acid, deoxyguanylic acid, guanosine or deoxyguanosine, but not by any of the adenine derivatives. Adenylic acid appears, however, to spare guanylic acid. Cytidylic acid, deoxycytidylic acid, cytidine, deoxycytidine, uridylic acid or uridine would satisfy the requirement for a pyrimidine, while thymidine and thymine would not. The free bases guanine, cytosine and uracil would not replace their respective pentoside derivatives. These purines and pyrimidines were tested at a concentration of 50 mg/ml.

Similar fractionation of the NDF with trypsin and chymotrypsin has shown that it was contributing additional protein nitrogen which apparently can be replaced with greater exogenous amino acid supplements.

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[1] This work was supported under a fellowship granted by the Grass Trust for Research in Neurophysiology.

Some Dietary Effects on the Estrous Cycle of the Female California Pocket Gopher, Thomomys bottae navus Merriam

W. C. GUNTHER, Valparaiso University

Introduction

In recent years the effect of diet on the reproductive cycle of mammals has received increasing attention (1, 5, 11). Pioneering such work have been the studies of Greep (3) and others. Moore (9) reviews some of the dietary factors believed to be responsible for male sterility.

The male pocket gopher in California appears to have two basically different types of reproductive cycles (4). In the vicinity of Davis, California, where the land is irrigated during the dry season, gophers breed during the entire year. In unirrigated land gophers appear to breed on a strictly seasonal basis. While investigating the reproductive activity of male gophers living in irrigated land, Gunther (4) suggested that the influence of a habitat in irrigated fields may be responsible for the drastic shift from a strictly seasonal breeding behavior to a continuous cycle.

If the influence of habitat is responsible for a continuous breeding activity in gophers in irrigated fields, there are several factors or sets of factors within such a habitat which can be profitably investigated. In this paper a preliminary report on the effect of diet as a possible factor responsible for the continuous breeding activities of the female gopher will be considered.

Materials and Methods

The observations reported here were made from studies on a total of nine freshly captured female gophers. All animals were live-trapped in irrigated alfalfa fields on the University of California Farm at Davis, California, and were processed in the laboratories of the Department of Zoology, University of California, Davis, California.

Upon capture the animals were weighed, vaginal smears were taken and then the females were placed singly in solid-walled aluminum cages open at the top. Dirt to a depth of eight inches was placed in each cage, and was moistened from time to time. A metal trough was placed on top of the dirt, affording a covered, surface runway for the animals.

Weighing of the animals at time of capture and during the course of the experiment was deemed desirable in order to check against factors which might cause loss of weight and thus obviate the results of the experiment. Furthermore, since nothing was known of the age of these animals, it was necessary to establish an arbitrary weight limit of 90 grams or over to designate sexually mature females. This limit was set since only a small number of pregnant females weighing less than

90 grams had been captured, while animals over this limit were consistently pregnant.

In order to determine whether an easily recognized estrous cycle could be induced in the pocket gopher, comparable to that identified in the rat and guinea pig (7), three animals were given daily subcutaneous injections for one week of 100 RU of estradiol benzoate (Progynon-B, Schering Corporation). Two other females were injected daily for one week with 100 RU of estradiol benzoate plus 0.2 cc (1 mg) progesterone (Prolution, Schering Corporation). Vaginal smears were taken twice daily in order to trace the changes in the vaginal cycle.

During the period of injection each of the five animals was placed with a freshly captured male presumed to be in breeding condition. After the first week daily injections were discontinued, and similar dosages were given at different intervals in order to establish time limits for a complete estrous cycle. The animals were then permitted to recover. All animals were given plentiful supplies of the types of food listed in the following paragraph.

Upon recovery of the animals from the experiment outlined above, three animals were fed morning and evening with nothing but freshly picked green alfalfa. Two other gophers were given only rolled oats. Four additional gophers were given all types of food during the course of the experiment. Vaginal smears were taken twice daily of all animals in order to detect changes in the reproductive cycle. After a month of such treatment all animals were placed on diets containing plentiful supplies of green alfalfa, lab chow, pablum, carrots, rolled oats, and potatoes. Vaginal smears were taken morning and evening for another month.

Observations

During the period of injection with chemical estrogens, all injected females gave evidence of four clear-cut and readily recognizable stages. These are summarized below:

Stage IV — numerous polymorphonuclear leucocytes; occasional epithelial and cornified cells; area around genitalia indistinguishable from surrounding parts. (This is the condition of most animals captured fresh from the field, and in all animals above before injections were begun.)

Stage I—numerous to few polymorphonuclear leucocytes; occasional epithelial cells; many cornified cells; area around genitalia becoming distinguishable from surrounding parts but vulva not turgid.

Stage II—All cornified cells, not in large sheets; vulva turgid; clitoris prominent; entire genital area swollen.

Stage III—few polymorphonuclear leucocytes; no epithelial cells; cornified cells now in sheets; genital area still prominent but less so than in Stage II; vulva not turgid.

The transitions from Stage IV to Stage II were induced by injections of estradiol benzoate in the case of three animals and by estradiol benzoate plus progesterone in the case of two females. As long as injections continued the animals remained in Stage II. Upon withdrawal of the estrogens Stage II gave way to Stage III and finally to Stage IV. Stages I and II could again be elicited by injections of estrogens, with Stages III and IV following upon withdrawal. It was impossible to establish narrow time limits for the successive stages at the intervals when smears were made. In general, three days after injections were begun the animals were all in Stage II. Two days after withdrawal of the estrogens the females were in Stage IV.

When any of the injected females were placed with a freshly captured male gopher presumed to be in breeding condition during any of the above stages, fighting inevitably followed. Some battles were so severe that the female had to be removed. When fighting was mild, the female was kept with the male overnight or longer. No spermia were detected in the vaginal smears at these times, so mating had evidently not taken place.

Since nothing, therefore, is known of the stage during which actual mating occurs in the gopher, it will not be practical to designate the above stages as diestrum, estrum, etc.

The results recorded from observations on the animals given different diets are summarized in Table 1. As can be seen, diet apparently had no effect in producing changes in the vaginal cycle.

Discussion

Several interesting effects of diet on reproduction have been recorded by different investigators. Moore (9) reviewed some of the effects of nutritional deficiencies, comparable in their scope to the role played by endocrines and other environmental factors in some cases, and resulting in male sterility, or at least in a reduction in fertility. Other investigators could find no support that the materials with which they worked had any effect on reproduction (6, 10). Walker and Wirtschafter (12) established that the rat embryo cannot survive in the presence of a lathyrus factor from a pea-pellet diet beyond the 16th day of gestation. Ershoff (2) showed that the deleterious effects of alpha-estradiol on the immature rat ovary could be counteracted by feeding dried alfalfa.

It has been assumed that the female pocket gopher in irrigated lands in California is polyestrous, breeding throughout the year. In a recent report Gunther (4) stated that pregnant females were captured during every month of the year. Miller (8) reported similarly, and attempted by statistical analysis to establish reproductive cycles and rates in this animal.

The vaginal smear technique is routinely used in testing for estrous cycles in such laboratory animals as the rat and guinea pig. As was indicated above, clear-cut stages are easily recognized in gophers injected with estrogens. Since no criteria exist relative to the determination of an estrous cycle in the female pocket gopher, it was hoped that by artificially inducing such a cycle, readily recognizable stages could be recorded, and such information used in determining the phases of estrum of gophers fresh from the field and under dietary experiments in the laboratory. If such a cycle, artificially determined, is similar to that in rats, it might be valid to assume that such events occur normally in the estrous cycle of the gopher.

TABLE 1. Observations on animals maintained on different diets.

Animal No.	Weight (gr)	Diet	Vaginal smear (Stage)
1	Varied from 97-124	Green alfalfa	IV
2	" " 94-110	" "	"
3	" " 99-118	" "	"
5	" " 110-120	Rolled oats	"
17	" " 112-117	" "	"
All above	Same variations	All foods	"
20	Varied from 133-162	" "	"
35	" " 133-172	" "	"
39	" " 107-125	" "	"
40	" " 131-155	" "	"

As is indicated from the results of this investigation (Table 1), green alfalfa alone, or in combination with other foods, has no apparent effect on the estrous cycle of the female pocket gopher (if the determination of the estrous cycle by the methods employed be considered valid). This statement must, however, be qualified by a consideration of the conditions under which the experiments were conducted. While every effort was made to simulate the natural environment of the gopher, it should be recalled that the animal was still in an artificially created habitat. While such conditions as temperature and humidity were controlled as much as possible, it by no means follows that the animal in the field would have the same conditions. Furthermore, the amount of digging and the space for roaming severely limited the gopher in terms of exercise in the laboratory. Handling of the animals in order to make vaginal examinations also created another situation which the gopher does not face in the field. It must also be emphasized that although female gophers can be made to produce an estrous cycle through injections of hormones similar to that observed in the natural, and in the artificially induced, cycle in the rat, it by no means follows that these gophers undergo the same cycles in their natural environment.

Since these animals spend 99 percent of their time underground, it is possible that instead of eating green alfalfa (the parts of the plant above ground) they exist on nothing but the roots. The factor controlling the estrous cycle might lie resident within the roots. This possibility was not probed in this investigation. It has been observed, however, that gophers frequently pack their burrows with green alfalfa. On the other hand, fields of alfalfa have been noted with isolated stands of blighted, shrivelled, and yellowed alfalfa stalks. When such areas were examined carefully, it was noted that gopher diggings were numerous throughout the stand, and when the alfalfa plant was pulled from the ground it was seen that the roots had been entirely gnawed away.

A possibility exists that the female gophers under consideration were already pregnant, in which case a Stage IV would normally appear in the vaginal smear. Upon autopsy of the animals, no evidence of pregnancy was noted. Fresh placental scars or corpora lutea were absent. There was no indication of recently resorbed embryos. Furthermore, if resorption of the embryos had occurred, there should have been ample time for recovery of the uterus and re-establishment of a normal sexual cycle.

Finally, it may be postulated that psychological factors intervened, thus effectively preventing the appearance of a normal estrous cycle and consequent laboratory matings of these animals. Even when given a normal environment, or as nearly normal as laboratory conditions permit, gophers inevitably fight when placed together in a cage in the laboratory. This was true when females were injected either with estradiol benzoate alone or with estradiol benzoate plus progesterone. Regardless of sex, the stronger (larger) usually attempted to kill the weaker (smaller).

Summary

1. An artificially induced estrous cycle has been described for the female pocket gopher.

2. Females injected with estradiol benzoate, or with estradiol benzoate plus progesterone, did not mate with freshly captured males in the laboratory.

3. Animals maintained on diets of fresh alfalfa alone, or with lab chow, pablum, rolled oats, carrots, and potatoes added, show no indications of undergoing a normal estrous cycle under the experimental conditions listed.

4. It is postulated that factors other than diet alone are responsible for the abandonment of the estrous cycle of female pocket gophers and their consequent failure to mate in the laboratory. Such factors may be psychological.

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A New Race of Wood Pewee from Mexico

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The breeding Wood Pewees of the southwestern Mexican State of Guerrero have been called *Contopus richardsonii richardsonii* by Griscom (2); *C. r. sordidulus* by Ridgway (5) and Blake (1); *C. virens sordidulus* by Hellmayr (3). In identifying the W. W. Brown collection of Guerrero birds at the California Academy of Sciences, I found myself in disagreement with all of these authorities. The Guerrero bird is:

Contopus sordidulus griscomi new subspecies

Subspecific characters.—Breeding adults paler and grayer on breast and flanks, whiter on throat, paler and more olivaceous on back and crown than either *C. s. veliei* or *C. s. sordidulus;* smaller-billed than *C. s. peninsulae;* much paler both dorsally and ventrally than *C. s. saturatus;* paler both dorsally and ventrally, with a darker mandible, and with a relatively shorter tail than *C. virens.* Fall immatures slightly paler and grayer than *C. s. veliei;* definitely paler, less blackish, than *C. s. saturatus;* and definitely paler and grayer, less brownish, than *C. s. sordidulus.* Wing length averaging shorter than in *C. s. saturatus, C. s. veliei,* and *C. s. peninsulae* but longer than in *C. s. sordidulus.* Tail, as measured by length beyond longest upper tail covert, averaging longer than in *C. s. peninsulae,* shorter than in *C. s. veliei* and *C. s. saturatus,* and similar to *C. s. sordidulus.* Bill, best measured as length from nostril, smaller than in *C. s. peninsulae, C. s. veliei,* and *C. s. saturatus,* and similar to *C. s. sordidulus.*

Type.—California Academy of Sciences, adult male, taken May 9, 1951, at Chilpancingo, Guerrero by W. W. Brown. Wing 86 mm., tail 61 mm., bill from nostril 9.2 mm., tail beyond longest upper tail covert, 29 mm.

Range.—Known only from Chilpancingo and Cuapongo, Guerrero. Specimens examined varied in collection dates from April 1 to August 2. Winter specimens not seen, but presumably winters in South America. Specimens intermediate between this race and *C. s. veliei* and/or *C. s. sordidulus* have been examined from Nayarit, Sinaloa, Michoacan, Zacatecas, and Durango.

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[1] Dr. Robert T. Orr helped me in many ways at the California Academy. Dr. Allan R. Phillips gave me much important help, including the use of his voluminous original data. The curators of the University of California Museum of Vertebrate Zoology gave me free access to the collection under their care. For the loan of specimens I am indebted to the Carnegie Museum of Pittsburgh, the American Museum of Natural History, Allan R. Phillips (personal collection), Dr. George M. Sutton (personal collection), and Mr. Lewis D. Yaeger (personal collection).

Remarks.—The comparisons of adults were made with May, June, and July specimens; of immatures with July through October specimens. For measurements of the wing and tail length, see Tables I and II. On many adult specimens I made seven measurements. Length of

TABLE I.

Measurements in millimeters of the chord of the wing of May, June, and July adults. Averages in parentheses.

	♂'s	♀'s
Guerrero, 17 ♂ and 23 ♀ *C. s. griscomi*	82-88 (84.6)	77-82 (79.3)
Arizona exclusive of southeastern corner, 25 ♂ and 18 ♀ *C. s. veliei*	82-90 (86.7)	80-84 (82.6)
Texas, Utah, Idaho, British Columbia, Oregon and California, 19 ♂ and 15 ♀ *C. s. veliei*	84-89 (86.8)	80-84 (82.3)
Chiapas, eastern Guerrero, and eastern Zacatecas, 2 ♂ and 1 ♀ *C. s. sordidulus*	82-84 (83.0)	78
Southeastern Arizona and northwestern Chihuahua, 18 ♂ and 12 ♀ intermediates	83-90 (86.3)	77-85 (81.1)
Durango and Zacatecas, 4 ♂ and 1 ♀ intermediates	83-87 (84.2)	81
Sinaloa, Michoacan, and Nayarit, 5 ♂ and 4 ♀ intermediates	84-90 (87.4)	80-83 (81.2)
Alaska and British Columbia, 3 ♂ *C. s. saturatus*	84-88 (85.3)	
Southern Baja California, 2 ♂ *C. s. peninsulae*	86-86 (86.0)	

TABLE II

Measurements of the tail in millimeters, as measured by length beyond longest upper tail covert. Averages in parentheses. May, June and July adult males only.

Guerrero, 2 *C. s. griscomi*	29-32 (30.5)
Sinaloa, Nayarit, Durango, Michoacan, Tamaulipas, and Nuevo Leon, 8 intermediates	29-34 (31.0)
Southeastern Arizona, 11 intermediates	28-34 (31.5)
Arizona exclusive of southeastern corner, 17 *C. s. veliei*	29-34 (31.9)
Texas, Utah, Oregon, Idaho, and British Columbia, 13 *C. s. veliei*	31-34 (32.9)
Baja California, 2 *C. s. peninsulae*	26-28 (27.0)
Northeastern Guerrero, 1*C. s. sordidulus*	29

bill from nostril, length of tail beyond longest upper tail covert, and wing length showed definite but not particularly significant geographical variation. Length of tail, exposed culmen, primary 7 minus primary 10, and primary 9 minus primary 4 (these last 2 designed to measure roundedness of the wing) did not show definite geographical variation. The measurements given in Tables I and II were all taken by myself except for those from Arizona, most of which were made by Allan R. Phillips. I have followed Phillips and Parkes (4) in rejecting the name *richardsonii* and substituting therefor the specific name *sordidulus* and subspecific name *veliei.*

Synopsis of the Western Wood Pewees of Mexico

Contopus sordidulus veliei.—Breeds in northern Baja California, Sonora, Coahuila, Tamaulipas, and Nuevo Leon; a common migrant farther south. Paler than *saturatus* and *sordidulas,* but darker than *griscomi* and *peninsulae.*

C. s. peninsulae.—Breeds in southern Baja California. As pale as *griscomi,* but distinguishable from that and all other races by the larger bill.

C. s. griscomi.—See above.

C. s. sordidulus.—Breeds in extreme eastern Zacatecas (Lulu), Hidalgo, Puebla, Vera Cruz, northeastern Guerrero (Taxco), Morelos, Oaxaca, and Chiapas. Darker than the preceding races, especially on the crown, and also browner in the immature plumage.

C. s. saturatus.—The Alaskan race occurs fairly commonly in western Mexico as a migrant, as noted by Van Rossem (7). Specimens examined were: Near Zacatecas City, Zacatecas, September 22, 1955; Chilpancingo, Guerrero, September 11, 1944, October 17, 1938, May 1, 1945, August 19, 1937. Darker, blacker than all other races.

C. s. veliei x *sordidulus* x *griscomi.*—The Wood Pewee population of southeastern Arizona, southeastern Sonora, and Chihuahua was named *placens* by Van Rossem (6 and 7). I have, in the past (Webster and Orr, 8 and 9), recognized *placens,* adding Durango and western Zacatecas to the breeding range of the race, although I was well aware that southeastern Arizona birds are difficult to distinguish, even in series, from those of California. And, unfortunately, the type locality of *placens* is in Arizona. In view of the two well-marked races now recognized in southern Mexico, it now seems more sound to regard this area as one of intergradations and to relegate *placens* to the synonomy of *veliei.*

Specimens Studied

C. s. veliei: British Columbia, 15; Oregon, 7; California, 65; Idaho, 3; Utah, 4; Brewster County, Texas, 7; Guerrero, 12 (April); Chiapas, 1 (April); Tres Marias Ids., 1 (May 5, 1897); Michoacan, 1 (April); Vera Cruz, 1 (April).

C. s. veliei, intermediate toward *sordidulus* and/or *griscomi:* Southeastern Arizona, 10; northwestern Chihauhau, 5; Nuevo Leon, 1; Tamaulipas, 1.

C. s. griscomi, intermediate toward *sordidulus* and/or *veliei:* Durango, 4; western Zacatecas, 2; Nayarit, 6; Sinaloa, 3; central Michoacan, 2 (Patzcuaro).

C. s. griscomi: Guerrero, 62 (April, 21; May, 26; June, 10; July, 4; August, 1).

C. s. sordidulus: Eastern Zacatecas, 1; Hidalgo, 1; Pueblo, 1; Chiapas, 1; northeastern Guerrero, 1 (Taxco).

C. s. peninsulae: Baja California, 2 (Sierra de Laguna).

C. s. saturatus: Alaska, 4; British Columbia, 4; Arizona, 1 (September); Zacatecas, 1; Guerrero, 4; New Mexico, 1 (August).

This list includes only the material studied at the California Academy of Sciences and Museum of Vertebrate Zoology in 1955-56 and at Hanover College in the fall of 1956. In addition, series of Arizona and Sonora *veliei* and of Baja California *peninsulae* and a few southern Mexico *sordidulus* had previously been examined.

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The Effect of Crystalline Glucagon on the Blood Sugar of the Fowl[1]

Bruce E. Beekman, Indiana University

Kimball & Murlin (4) discovered a hyperglycemic factor in extracts of the pancreas more than 30 years ago, but only in the last decade has this substance, glucagon, been definitely established as a second pancreatic hormone. Evidence from several lines of approach support the earlier assumption that glucagon has its origin in the alpha cells of the Islets of Langerhans (2, 9).

Glucagon has been extracted from the pancreas of mammals, teleosts and birds (1, 5, 10). The existence of glucagon in a wide variety of vertebrates has therefore been established. The relative importance of the hormone's role in regulating carbohydrate metabolism in various groups of vertebrates is still unknown. Glucagon's primary physiological action in the regulation of carbohydrate metabolism appears to be an enhancement of liver glycogenolysis, thereby elevating the blood sugar level (8).

The effect of injected crystalline glucagon on blood sugar level has been described for some mammalian species (6, 7). Of the mammals thus far investigated, the cat seems to be the most sensitive to small doses of the hormone. The purpose of the investigation reported here was to determine the sensitivity of the fowl to the hyperglycemic effect of crystalline glucagon.

Materials and Methods

White Leghorn cockerels ranging in weight from 600 to 1100 grams, and in age from 8 to 12 weeks, were used in this study. The birds were raised in the laboratory from day old chicks on a constant diet of a commercial growing feed. Twenty-four hours before they were to be used, their food was withdrawn. After a 12 hour fast, the birds were weighed, marked and allowed to feed for the remaining 12 hours prior to treatment.

The crystalline glucagon[1] was dissolved in water after adjusting the pH to 9.0-9.5 with 0.1 N NaOH. The dosages of hormone used were 0.1, 1.0, 10 and 25μgm./kg. fasted body weight. Injection was into the right wing vein in a volume of 0.05 ml. per kg. Blood samples were taken, as previously described (2), from the left wing vein immediately before injection and at five minute intervals after treatment until the maximum response had been reached. Blood sugar was determined by the Folin-Malmros micro-method as adapted for the photoelectric colorimeter by Horvath and Knehr (3).

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[1] Contribution No. 622 from the Zoology Dept., Indiana University.

[1] Lot No. 258-234B-43, Lilly Research Laboratories, Eli Lilly Co., Indianapolis, Indiana. Supplied through the courtesy of Dr. W. R. Kirtley.

Results

A significant hyperglycemia was obtained with the 0.1 μgm. dose. (Fig. 1) The maximum response to this dose was observed at 5 minutes after injection (Table 1). The interval between time of treatment and the time at which the maximum response for each dose was reached, was increased as the dosage was increased (Table 2).

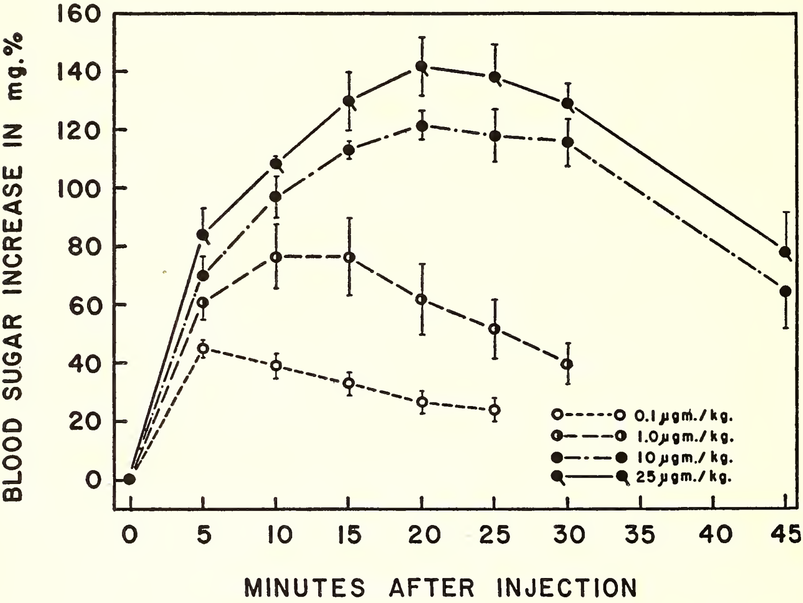

Figure 1: The mean hyperglycemic response of the White Leghorn chicken to crystalline glucagon administered i.v. at time 0 in 0.05 ml. water at pH 9.5. The standard error of the mean values is also shown.

When the log of the dose is plotted against its maximum blood sugar increase, one obtains a straight line for the dosage range used in this experiment. (Fig. 2)

Staub *et al.* (6) have reported that in the cat, a dose of 0.2 μgm. increases the blood sugar 45 mg.%. In the chicken this same response is obtained with one half that amount, or 0.1 μgm. The absolute maximum response in the cat is reached with 1-2 μgm. (6), whereas in the chicken the absolute maximum response would be obtained by a dose somewhere above 25 μgm.

This high sensitivity and wide dosage response range of the bird to glucagon, together with the report that the bird pancreas contains approximately six times as much glucagon as the mammalian pancreas (10), suggests that glucagon's role in the hormonal regulation of carbohydrate metabolism should not be overlooked when considering possible differences between birds and mammals in respect to this regulation.

TABLE 1. The hyperglycemic response of the White Leghorn chicken to graded doses of crystalline glucagon.

Dose	Number of birds	Initial blood sugar[1]	Blood sugar increase from initial level in mg.% at:						
			5 Mins	10 Mins	15 Mins	20 Mins	25 Mins	30 Mins	45 Mins
0.1 μgm./kg.	6	187[2]	45	39	33	27	24		
		± 2[3]	± 3	± 4	± 4	± 4	± 4		
1.0 μgm./kg.	6	187	61	77	77	62	52	40	
		± 3	± 6	±11	±13	±12	±10	± 7	
10 μgm./kg.	6	182	70	97	113	122	118	116	65
		± 9	± 7	± 7	± 3	± 5	± 9	± 8	±13
25 μgm./kg.	6	180	84	108	130	142	138	129	78
		± 3	± 9	± 3	±10	±10	±11	± 7	±14

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[1] mg./100 ml. whole blood.

[2] mean value.

[3] ± standard error of the mean.

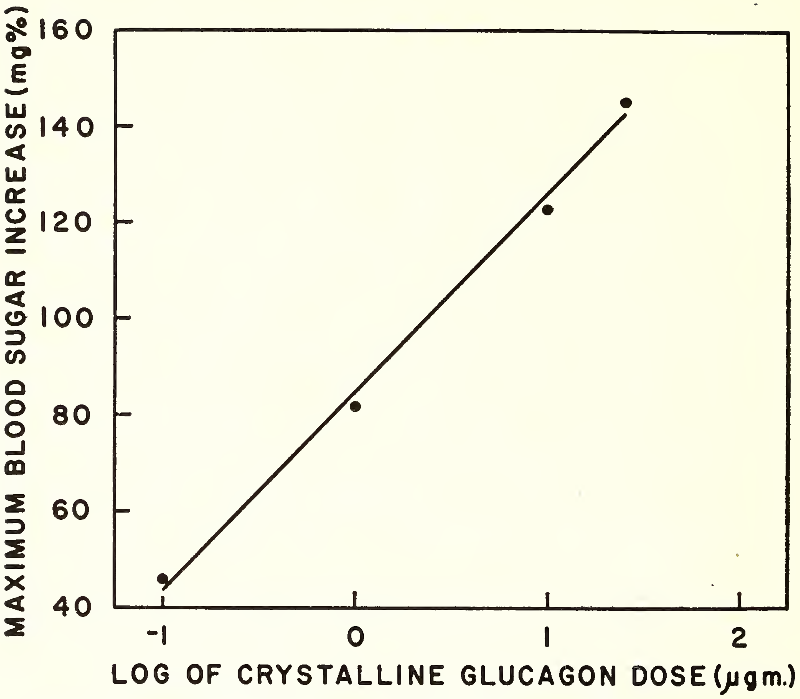

Figure 2: The log dose-mean maximum hyperglycemia produced by crystalline glucagon in the White Leghorn chicken. Hormone administered i.v. in 0.05 ml. water at pH 9.5.

TABLE 2. The maximum response of the White Leghorn chicken to graded doses of crystalline glucagon.

Dose	Number of birds	Initial blood sugar[1]	Maximum blood-sugar increase[1]	Time when maximum observed[2]
0.1 μgm./kg.	6	187[3] ± 2[4]	46 ± 4	5
1.0 μgm./kg.	6	187 ± 3	82 ±12	10
10 μgm./kg.	6	182 ± 9	123 ± 6	20
25 μgm./kg.	6	180 ± 3	145 ±12	20

---

[1] mg./100 ml. whole blood.
[2] mins. after treatment.
[3] mean value of six determinations.
[4] ± standard error of the mean.

Summary

A significant hyperglycemia is produced with 0.1 μgm. of crystalline glucagon in the White Leghorn cockerel. The log dose-maximum response curve is linear for the dosage range used (0.1 μgm.-25 μgm.). An increase in dosage increases the interval between treatment and the time when the maximum response is reached. The sensitivity of the chicken to glucagon appears to be higher than that of mammals.

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INDEX

Accelerater, intersecting beam, with storage ring, 299.
Acetylenic alcohols, determination of esters of, 91.
Acidity of trichloroacetic acid, 86.
Alpha-conidendrin, bacterial dissimilation of, 55.
Alpha particles, scattering of 19-Mev, by Ni, Al, A and Cu, 297.
Aluminum in the qualitative test for acetate, 98.
Amphibians and reptiles, distribution in Indiana and Illinois, 328.
Analysis by extraction and high frequency measurement, 81.
Analysis of *Helianthus* hybrids, 306.
Anomaly occurring on the Atlas, racial significance, 45.
Anthocyanin synthsis, 61.
Anthophilous insects of Indiana: I. A preliminary annotated list of the Apoidea, 125.
Anthropology division, 45.
Are we doing a job (soil science), 230.
Areal differentiation of Indiana counties, 159.
Aromatic thiols, improved procedure for the preparation of, 79.
Auditory fatigue, 323.
Azotobacter, oxidation of acetate by extracts of, 56.

Bacteriology division, 55.
Barber, S. A., 242.
Beals, H. O., 63.
Bechert, C. H., 286.
Bechtel, A. R., memorial, 27.
Beekman, B. E., 341.
Behrens, O. K., 77.
Bellman, S., 95.
Berry, R. N., 325.
Billman, J. H., 78.
Birds and grasslands of western Mexico, 329.
Blassingham, E. J., 47.
Bleuler, E., 297.
Bloomington, Indiana, water supply problems of, 188.
Botanical forays to Florida, 318.
Botany division, 61.
Bowman, S. E., 252.
Breneman, W. R., 329.
Bretz, H. W., 55.
Brodie, H. J., 65.
Bromer, W. W., 77.
Bromination of carbostyrils, 80.
Brumbaugh, J. H., 300.
Bryan, W. L., memorial, 28.
Burkett, H., 78, 86.
Bushnell, T. M., 246.
Buss, A., 324.

Calumet region, manufacturing, 209.
Campaigne, E., 79.
Cancellaceae, wood anatomy of, 63.
Carterette, T. S., 326.
Celloidin for the study of leaf surfaces, 74.
Ceratopteris pteridoides, geographic distribution of, 62.
Chalkland agriculture, recent changes in, 157.
Chandler, L., 112.
Chemistry division, 77.
Chicago-Heights, Illinois, 209.
Christy, O. B., 18, 27.
Clark, J. A., 6, 9, 13, 19.
Clay minerals in some glacial lacustrine sediments, 179.
Cleland, R., 15.
Clevenger, S., 61.
Coats, Nellie, 9, 14.
Cole, R. O., 291.
Coleoptera, records of, 115.
Conservation of
  Man in Indiana, 252.
  Germplasm of domestic species, 256.
  History of forest, in Indiana, 261.
  Recreational and scenic resources, 268.
  History of water, in Indiana, 286.
  History of soil, service, 291.
Cook, D. J., 80.
Coordination studies: dipyridylamine and 3,3'-iminobispropylamine, 95.
Correll, M., 297.
Cottingham, J. O., 305.
Counties, economic importance of Indiana's, 159.
Crowder, H., 63.
Crowell, S., 328.

Daily, F. K., 11, 18.
Daily, W. A., 6, 11, 19, 300.
Davis, J. J., 104.
Deay, H. O., 108.
Decay, beta, of Tb^{161}, 298.
Deiss, C., 18.

DenUyl, D., 261.
DeVol, C. E., 62.
Diehl, F. P., 141.
Dietary effects on the estrous cycle of the female California pocket gopher, 331.
Dinoflagellate, *Peridinium Volzii* f. *vancouverense* (Wailes), 300.
Dinsmoor, J. A., 324.
Diplura and Protura in Indiana, 112.
Dipole fields, novel orientations of, 297.
Dippell, R. V., 60.
Discrimination learning, sampling of common elements in, 326.
Downie, N. M., 115, 324.
Drives in raccoons, 325.
Drummond, R. R., 167.
Duncan, W. G., 230, 231.
Dunkin, J., 74.

Edwards, P. D., 17.
Effects of deficiency and luxury feeding on corn hybrids, 231.
Egan, J. P., 323.
Entomology division, 100.
Equations, integral, for transition matrices in the static meson theory, 298.
Esters of acetylenic alcohols, determination of, 91.
Estrous cycle of California pocket gopher, dietary effect on, 331.
Eugymnanthea, the hybrid that lives in a clam, 328.
European corn borer, sex of moths taken at light traps, 108.
Everly, R. T., 100.

Farm plannning in relation to soil conservation in Indiana, history of, 252.
Farquharson, L., 318.
Figurine heads, Mexican, 53.
Film impression method for observation of minute features of wood anatomy, 63.
Fischer, R. B., 81.
Fishes, Indiana history of, 275.
Flavonols of *Implatiens balsamina*, 61.
Fletcher, R. I., 57.
Forces between strange particles and nucleons, 299.
Forest conservation, in Indiana, history of, 261.
Fukada, N., 298.
Fumigation chambers, circulation fans for, 141.
Fungi, higher, of Marion county, Indiana, VIII, 305.

Gailor, O., 297.
Geology and geography division, 157.
Gerjuoy, H., 324.
Gerking, S. D., 275.
Ghost states in field theory, 299.
Gibberellic acid, shoot elongation assay for, 62.
Girton, R. E., 6, 9, 12, 35.
Glucagon
  Effect of crystalline, on blood sugar of fowl, 341.
    Structure of, 77.
Gould, G. E., 147.
Gries, G. A., 62.
Grollig, F. X., 53.
Guard, A. T., 300, 306.
Gunther, W. C., 331.

Hagen, Jr., C. W., 61.
Hall, M. T., 321.
Hamilton, J. H., 298.
Hart, J. F., 157, 195.
Heiser, C. B., 9, 15.
Helianthus hybrids, 306.
Herzog, G., 46.
Heterocyclic compounds via, 1,1,1-trichloro-3-nitroprapanol, 79.
Higgens, C. E., 62.
History of
  Farm planning in relation to soil conservation in Indiana, 252.
  Richmond scientific association, 252.
  Forest conservation in Indiana, 261.
  Study of fishes in Indiana, 275.
  Water conservation in Indiana, 286.
  Soil conservation service, 291.
History of science division, 252.
Hoffer, G. N., 231.

Index, 348.
Indiana, road patterns of, 192.
Insects of Indiana in 1956, 104.
Instructions for contributors, 346.
Interests, vocational, for engineers, 324.
Introgression among three species of *Viburnum*, 300.

Jackson, R. C., 306.
Johnson, Jr., J. I., 323.
Johnson, W. H., 9, 10, 19, 330.
Johnston, R. B., 50.
Josten, J. J., 56.

Keyform, catene-drainage profile in pedological taxonomy, 246.
King, L. J., 252.
Kingsbury, T., 157.
Kinsey, A. C., memorial, 30.
Klages, M. G., 232.
Klein, A., 61.
Konetzka, W. A., 155.
Kosolsombat, S., 81.
Kovacs, J., 298.

LaBarge, D. L., 326.
Lake levels, maintaining, with well water, 157.
Lal, A., 204.
Langer, L. M., 298.
Laubengayer, R. A., 6, 9, 12, 19.
Lefler, R., 16.
Leth, A., 95.
Lichtenberg, D. B., 299.
Light traps, sex of European corn borer taken at, 108.
Limestone, measurement of fineness of agricultural, 242.

McGuire, J. M., 62.
McMichael, E. V., 45.
Macklin, J. M., 152.
Macronucleus structure of *Paramecium aurelia* by electron microscopy, 60.
Magnetic fields suggested by other prominence, 297.
Manufactural geography of Chicago-Heights, Illinois, 209.
Markle, C. A., 301.
Markle, M. S., 318.
Marshall, G. E., 103.
Martin, E., 297.
Martin, Jr., W. C., 300.
Masses, determination of, from disintegration energies, 297.
Mathers, F. C., 98.
Meibohm, A. W., 95.
Membrane potential, effect of inhibitors, 330.
Memorials
  Bechtel, A. R., 27.
  Bryan, W. L., 28.
  Kinsey, A. C., 30.
  Miller, S. J., 31.
  Mull, B. R., 32.
  Tucker, W. M., 33.
Meyer, A. H., 209.
Michaud, H. H., 15, 268.
Michels, K. M., 325.
Migration and population change in Indiana, 195.
Miller, C. A., 330.
Miller, J. D., 323.
Miller, P. F., 209.
Miller, S. J., memorial, 31.
Mineralogy of Indiana soils, survey of, 232.
Minton, Jr., S. A., 328.
Mitchell, A. C. G., 297.
Mizelle, J., 6, 18.
Montgomery, B. E., 125, 152.
Moore, H. B., 141.
Mull, B. R., memorial, 32.
Murphy, I. A., 78.
Murphy, R., 86.
Murray, H. H., 179.
Music and values in some Indian cultures, 46.
Nelson, G., 79.
Nelson, O. E., 64.
Neumann, G. K., 45.
Newman, J. E., 231.
Newton, R. G., 299.

Oak wilt in southern Indiana, 63.
Ohlrogge, A. J., 230.
Osborn, S. W., 79.
Osborne, Jr., C. E., 91.
Osmun, J. V., 141.

Paramecium multinucleatum, purine and pyridin requirement for, 330.
Parfitt, S. D., 78.
Pedological taxonomy, catena-drainage profile keyform as reference, 246.
Penicillium, color change induced by action of light, 63.
Petri dish cover, improved, 57.
Pettay, L., 45.
Phillippe, M. M., 232.
Physical types of certain middle Mississippi and Southeastern groups, 50.
Physics division, 297.
Pigment production in flowers of *Impatiens balsamina*, 61.
Pituitary gland, effect of sex steroids on gonadotrophic content, 329.
Plant dispersal, role of raindrops in, 65.
Plant taxonomy division, 300.
Porter, C. L., 63.
Postlethwait, S. N., 64, 74.
Population statistics bearing on a Fort Ancient-Shawnee Linkage, 45.
Population trends in Indiana villages of 1,000-2,000 population in 1950, 204.
Presidential address, 35.
Protura and Diplura in Indiana, 112.
Psychology division, 323.

Radioactivity, atmospheric, from Indiana soils, 231.
Recreational and scenic resources, 268.
Red clover insects, control with new insecticides, 100.
Reduction in effect of prior exposure on escape-from-shock training, 324.
Relation patterns of QRS complex to rote learning, 325.
Repaske, R., 56.
Richmond scientific association, history of, 252.
Riddell, J. A., 62.
Riedhart, J. M., 63.
Roach exposure to chemically treated surfaces, 141.
Robinson, R. L., 298.
Ross, M. H., 299.

Rural level-of-living indexes in Indiana counties, a comparative study, 167.

Sawfly, *Neodiprion sertifer*, 101.
Scarseth, G. D., 230.
Schall, L. A., 231.
Schockel, B. H., 159.
Schuder, D. L., 101.
Seidlitz, L., 297.
Separator for sampling the soil fauna, 152.
Shiveley, J. M., 230.
Sinn, L. G., 77.
Smith, A., 326.
Smith, J. M., 179.
Smith, P. W., 328.
Smith, W. G., 298.
Soil conservation and related events, chronological history of, 291.
Soil science (affiliate of geology and geographical division), 230.
Sonneborn, T. M., 60.
Sorter, P., 80.
Speech communication, operating characteristic in, 323.
Starkey, O. P., 192.
Staub, A., 77.
Stearns, F., 63.
Stephenson, W. K., 330.
Stove, J., 55.
Strawberry virus and insect vectors, 103.

Talvenheimo, G., 232.
Taylor, J. G., 108.
Temperature effect on survival of mixtures of *Escherichia coli* substrains, 55.
Temperature-fertilizers interactions with corn, 230.
Tendam, D. J., 297.
Termite rearing method, 141.
Thackray, R. I., 325.
Three types of training, probability of positional response of, 326.
Tinkle, W. J., 256.
p-Toluenesulfonylhydrazide and its decomposition products, 78.
Tucker, W. M., memorial, 33.
Turpin site, notes on the ceramic material from, 45.

Vacuum trajectory compared with actual trajectory, 297.
Variations
  In *Helianthus angustifolius*, 300.
  In genus *Hudsonia*, 321.
Virus disease for control of the European pine sawfly, *Neodiprion sertifer* (Geoff.), 101.
Visher, S. S., 188, 254.
Visual activity in raccoons, 323.

Wallace, F. N., 15.
Water conservation in Indiana, history of, 286.
Water supply problems of Bloomington, Indiana, 188.
Wayne county, vascular plants of, II, 301.
Weather records, use of punch cards, 231.
Webster, J. D., 329, 337.
Welch, W., 9, 14.
Welcher, F. J., 6, 9, 19.
Wells, H. B, 18.
Western Great Lakes region, the "New England Indians" in, 47.
Wheat grains, influence of age and maturation temperature of, on plant development, 62.
White, J. L., 232.
Wilson, T. K., 63.
Wilting in the corn plant caused by failure of metaxylem development, 64.
Wireworm populations as influenced by soil types, 147.
Wood pewee, new race from Mexico, 337.
Woodlands in Monroe county, Indiana, 170.
Words, scaling of, to describe personality, 324.

Yarion, D., 86.
Youse, H. R., 9, 15, 18.
Yuncker, T. G., 13.
Yunghans, R. S., 80.

Zakrzewska, B., 170.
Zeller, F. J., 329.
Zoology division, 328.